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Living Marine Legacy of Gwaii Haanas. II:

Marine Invertebrate Baseline to 2000 and Invertebrate-related Management Issues

N.A. Sloan,
P.M. Bartier and
W.C.Austin

December, 2001
Report 035

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Living Marine Legacy of Gwaii Haanas. II:

Marine Invertebrate Baseline to 2000 and Invertebrate-related Management Issues

by

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December, 2001

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Abstract

This is the second report in a series of baseline marine biological inventories for the Haida Gwaii (Queen Charlotte Islands) region including the proposed marine component of Gwaii Haanas National Park Reserve/Haida Heritage Site. We list the marine invertebrate species known from the intertidal to the deep-sea and map some of their distributions known to the end of 2000. The geographic information system contains ≈25,000 records of 2,503 invertebrate species from ≈2,900 localities in a spatio-temporal database. Regional biogeographic comparisons and invertebrate species-habitat generalizations are made. Aboriginal (Haida) uses of, and words for, invertebrates are recounted. All the archipelago's commercial and recreational invertebrate fisheries and their management are described. The contributions of marine invertebrate issues to future management of the Gwaii Haanas marine area, noteworthy data gaps and management recommendations are discussed.

Résumé

Ce rapport est le deuxième d'une série de documents de référence portant sur l'inventaire biologique des espèces marines de la région de Haida Gwaii (îles de la Reine-Charlotte), y compris la composante marine proposée de la réserve de parc national et du site du patrimoine haïda Gwaii Haanas. Nous y dressons la liste des espèces d'invertébrés marins connus qui peuplent la région comprise entre la zone intertidale et les eaux profondes, et nous présentons des cartes illustrant certaines aires de distribution connues à la fin de 2000. Notre système d'information géographique fait état de ≈25,000 occurrences de 2,503 espèces invertébrées dans ≈2,900 endroits recensés dans une base de données spatio-temporelles. En outre, le rapport présente le résultat de comparaisons biogéographiques régionales ainsi que certaines conclusions générales sur la biodiversité et l'habitat des invertébrés. De plus, nous y recensons les noms donnés aux invertébrés par les Autochtones (Haïdas) et l'utilisation qu'ils font de ces espèces. Il est aussi question de la façon dont sont gérées dans l'archipel la pêche commerciale et la pêche récréative de toutes les espèces répertoriées. Enfin, le rapport expose le rôle des invertébrés marins dans la gestion de la future aire marine de conservation Gwaii Haanas, fait état de lacunes dignes de mention dans la collecte de données et formule des recommandations pour la gestion.

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It is fitting that so many private sector, institutional and government agencies colleagues contributed to this baseline, for only through broad cooperation will marine area conservation be achieved in Canada. We are very grateful to Ms. Mary Morris (Archipelago Marine Research, Ltd., Victoria) who managed two contracts that evolved into the marine invertebrate database. Mr. Phil Lambert and Ms. Jan Cowan (Royal British Columbia Museum, Victoria), Dr. Jean-Marc Gagnon and Ms. Daniele Belisle (Canadian Museum of Nature, Ottawa) and Dr. Dale Calder and Mr. Don Stacey (Royal Ontario Museum, Toronto) executed contracts that yielded data on Haida Gwaii from their marine invertebrate collections. Special thanks to Phil Lambert for writing the Preface. Other contributing museums, listed in Appendix A, very kindly provided records of their Haida Gwaii invertebrate holdings. We wish to particularly thank Ms. Cindy Ahearn and Dr. David Pawson of the (U.S. National Museum of Natural History, Smithsonian Institution, Washington, D.C.), Dr. Gordon Hendler, Ms. Lindsey Groves and Ms. Leslie Harris (Los Angeles County Museum of Natural History, Los Angeles) and Dr. Rich Mooi, Mr. Bob Van Syoc and Ms. Liz Kools (California Academy of Science, San Francisco).

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Preface

This report brings to public view many records of marine invertebrates that have been submerged in museum collections and the literature for decades. I commend Parks Canada for this initiative. Invertebrates are often ignored in inventories even though they make up over 90 % of an area's animal species and, after plants, form the framework of ecosystems.

Some of our museum's specimens from Haida Gwaii were collected in March 1976 when staff from the then British Columbia Provincial Museum (now Royal British Columbia Museum) aboard the *C.S.S. Parizeau* did SCUBA surveys in northern British Columbia. Apart from some deep-water trawl surveys by government agencies, few shallow water scuba diving surveys had ever been done in this region. That experience shaped my appreciation for the complexity and diversity of the flora and fauna of this coast. It was an important milestone in my continuing study of marine invertebrates and helped me to grasp both the obvious and subtle differences between our southern and northern coasts. Having a specimen in a jar is one thing, but seeing it in nature deepens one's understanding.

We dived at eight locations around Haida Gwaii and immediately made several important discoveries. We collected a sea star, *Poraniopsis inflata*, known previously from farther south in deep water off Oregon. A brightly coloured sea cucumber which struck me as very different, I later described as a new species - *Parastichopus leukothele*. Later in 1976 we returned to Tasu Sound and collected at 16 more sites. Collection records of selected taxa were published but the majority remained as specimens in our collections. Since then, specialists have utilized them and discovered more new species and range extensions to Haida Gwaii waters. Other institutions and individuals have also surveyed these marine waters and deposited specimens in various museums. In the case of our collections, some records may not have been identified or verified by taxonomic experts and thus should be viewed with caution. Nevertheless, this report represents an important first step at setting a baseline that will allow others to build on this information, fill in the gaps, and verify or confirm the presence of rare or uncommon species.

With funding from Parks Canada, records from museums and other agencies around the continent have been transferred from paper or internal electronic databases into this document and its associated spatiotemporal database. It is very timely, with the proposed establishment of Gwaii Haanas National Marine Conservation Area and the possibility of oil exploration in Hecate Strait, that these data are synthesized into a baseline document that will reflect our present knowledge and allow us to detect changes in the future. The sections on traditional Haida knowledge, shellfisheries and management applications of invertebrate knowledge to marine area conservation provide a useful synthesis for forthcoming public consultations on Gwaii Haanas marine area establishment. Much has been said about how crucial, basic inventory knowledge is to the assessment of damage or change and yet funding seldom goes to these seemingly mundane pursuits. I applaud the major effort to produce the previous algae report, this one, and those that will follow.

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Royal British Columbia Museum

Executive Summary

"Gosh, there's an awful lot of work to make even the most cursory survey of this sort."
Ed Ricketts on marine biological surveys; Masset Inlet, June 1946 (Hedgpeth 1978)

This is the second report in a series providing baseline marine species inventories for the Haida Gwaii (Queen Charlotte Islands) region including the proposed marine component of Gwaii Haanas National Park Reserve/Haida Heritage Site. An assessment of the diversity of species (hereafter referred to as species biodiversity) is central when addressing Parks Canada's mandate to conserve representative samples of Canada's marine areas by maintaining ecosystem structure and function, while enabling multiple sustainable uses such as fisheries and tourism.

Establishing a georeferenced inventory is a necessary first step towards linking species biodiversity with habitat type and eventually understanding the ecosystem role of marine invertebrates in the region. Invertebrates are critical to the region's marine conservation, as they likely represent ≈90% of the animal species biodiversity. Accordingly, we list the benthic, pelagic and parasitic marine invertebrate species from the intertidal to the deep-sea (>3,600 m) and map some of their distributions known to the end of 2000. Our geographic information system (GIS) database contains ≈25,000 records, of 2,503 species, from 677 Families in 23 phyla recorded from ≈2,900 localities. Haida Gwaii is of marine biogeographical interest, as it represents the apparent northern limit of some northeast Pacific marine organism groups.

Beside the species biodiversity inventory, this report also includes the following:

- a review of Aboriginal (Haida) knowledge of, and words for, marine invertebrates;
- a discussion of regional marine invertebrate zoology history over the last 120 years;
- a synthesis of invertebrates' roles in regional marine biodiversity and biogeography;
- a detailed overview of Haida Gwaii invertebrate fisheries;
- an analysis of invertebrate issues relevant to future marine area management; and
- detailed bibliographies of source publications to enable further enquiry.

We describe regional marine invertebrate knowledge, synthesise this into an integrated overview in aid of conservation management, and recommend focus towards filling key knowledge gaps. This volume should function as a technical reference helping to define invertebrate issues in forthcoming public consultations on declaration of the Gwaii Haanas marine conservation area. We have tried to bring some clarity to the complexities of marine invertebrates and their attendant management issues for a wide readership (coastal communities, fishery sector, non-governmental organisations, agencies, universities) in an accessible and technically sound document. As well, the database facilitates the addition of new knowledge into a sound baseline that will long be a work-in-progress. As knowledge of the region improves, so should the quality of our marine area conservation decision-making.

INTRODUCTION

"A knowledge of the fauna and flora of an area must form the basis of all lines of biological investigation ..." W.C. Clements' (1933) introduction to the first regional marine species checklist

"We need to launch a major effort to measure biodiversity, to create a complete inventory of all the species ..." (E.O. Wilson 1987)

"An understanding of marine biodiversity is indispensable for advances in all fields of biology, including ecology, fisheries and aquaculture, conservation and pollution." (Grassle *et al.* 1991)

"Our first step should be to provide a description of what exists, an inventory." (Suchanek 1994)

"...the well-being of most natural ecosystems may depend ... on the myriads of less-heralded animals, most of them invertebrates ..." (New 1995)

"The experiences of each of us become a shared resource for all only if the stories are told, recorded and accessible." (Kingsford and Battershill 1998)

"......the first step in planning a MPA is the identification and mapping of habitat types and living marine resources." (NRC 2001)

A marine mandate of Parks Canada is in the proposed *Canada National Marine Conservation Areas Act*. This mandate is protection and conservation of representative samples of marine regions and includes maintaining ecosystem structure and function while permitting multiple sustainable uses, such as fisheries and tourism, within protected areas. As a necessary first step towards building understanding over the long-term, inventory of the diversity of species (hereafter referred to as species biodiversity) underpins marine conservation for Parks Canada (Sloan and Bartier 2001). We understand, however, that biodiversity is an overall concept within which species is but one level, as explained later in this report. Biodiversity work compliments Parks Canada's recently defined mandate towards ecological integrity as parks strive to become *"centres of ecological understanding"* (Parks Canada Agency 2000).

This is the first overview of marine invertebrates from the Haida Gwaii (Queen Charlotte Islands) region. Its scope is within the biogeographic ranges of various Northeast Pacific marine invertebrate fauna reviews (Morris *et al.* 1980; Austin 1985; Kozloff 1996; O'Clair and O'Clair 1998). Marine invertebrates comprise ≈90% of British Columbia's marine animal species and their diversity may be greatest in the nearshore coastal zone (Lambert 1994). Invertebrates also dominate the animal diversity of British Columbia's terrestrial and freshwater habitats (Scudder 1996). Invertebrates relate to all aspects of marine area conservation and we connect knowledge of marine invertebrates to the full array of management issues confronting Gwaii Haanas. Bruce Chatwin's biographer cited a suggestion that Chatwin suffered from *"beziehungswahn"* – a delirium of establishing connections (Sheakspear 1999). Well, thinking about the manifold roles of invertebrates in marine area conservation ushers one into a Chatwinesque delirium.

This report includes a Haida Gwaii marine invertebrate species biodiversity inventory in a spatio-temporal, geographic information system (GIS) database. We sought to provide taxonomic nomenclature and systematic arrangements that would be acceptable to the scientific community. Our commitment to conventions and protocols concerning nomenclature and systematics are described in the Methods.

This report covers the Haida Gwaii archipelago and contiguous regional waters including Dixon Entrance, Hecate Strait, Queen Charlotte Sound and westward into the Northeast Pacific to .145° W (based on research cruise reports). Hereafter we call this area the Haida Gwaii region. Species observations from Vancouver Island, the mainland (continental) British Columbia and Alaska coasts, mainland coast islands and inlets were excluded. The extent of the Haida Gwaii region respects Parks Canada's policy on understanding regional marine attributes not just those within conservation area boundaries (Parks Canada 1994). Habitat coverage is upper intertidal (including estuarine) to the deep-sea (to 3,660 m depth). Temporal coverage starts from the first published zoological and archaeological reports of the late 19th century to 2000. We acknowledge, however, that the archaeological record itself dates back ≈10,000 years BP (before present). Only species explicitly mentioned as collected in this region are included. We excluded those species for which the Haida Gwaii region is within their known geographic range, but have not yet been explicitly from the region. The only exceptions are those parasitic invertebrates living with highly mobile hosts where other members of the species are recorded from the region.

Establishing a georeferenced inventory is a necessary first step towards linking species diversity with habitat type and eventually understanding the ecosystem role of marine invertebrates in this region, including the proposed Gwaii Haanas National Marine Conservation Area. Our inventory compliments New's (1998) criteria for invertebrate inventories listed in Table 1. Beside the georeferenced species inventory, we include the following:

- a review of Aboriginal (Haida) knowledge, words and uses for marine invertebrates;
- a discussion of regional marine invertebrate zoology history over ≈120 years;
- a synthesis of invertebrates' roles in regional marine biodiversity and biogeography;
- a summary of all Haida Gwaii invertebrate fisheries;
- an analysis of invertebrate issues relevant to future marine area management; and
- detailed bibliographies of the source materials to facilitate further inquiry.

This is the second report in a series providing baseline marine inventories of Haida Gwaii with special reference to the living marine legacy of Gwaii Haanas National Park Reserve / Haida Heritage Site. The first report was on marine plants (Sloan and Bartier 2000) and proposed future reports include separate volumes on physical oceanography, plankton and productivity, marine fishes, marine birds and marine mammals.

A marine species biodiversity report addresses Gwaii Haanas' aspirations for public consultation and future management objectives for two main reasons:

- advises people on the current knowledge of marine invertebrate biodiversity, fisheries and invertebrate-associated ecosystem management issues; and
- establishes an initial marine invertebrate species biodiversity baseline in a spatio-temporal GIS database for subsequent investigators to augment and compare with other North Pacific regions.

Gwaii Haanas comprises the southern end of Moresby Island and associated islands in

Table 1. New's criteria for an invertebrate inventory matched with compliance statements according to this inventory.

New's[1] Criteria	*Notes on Compliance According to this Inventory*
Clear definition of objectives	*To establish a complete historical baseline on the marine invertebrate species of Haida Gwaii in a spatial (GIS) and temporal database (enabling addition of new data) and accompanied by a discussion of key marine invertebrate-related conservation management issues*
Thorough knowledge of background literature, using existing collections, identifying data gaps, avoiding repetition	*The complete regional literature was accessed, museum collections were widely surveyed, data gaps identified – all for the first time for Haida Gwaii*
Project continuity (funding and lead time)	*Parks Canada is committed to maintaining and augmenting the GIS database*
Classification and choice of representative habitats	*Our GIS will facilitate layering habitat data over invertebrate distribution data*
Stability of areas of the survey	*The Gwaii Haanas portion of Haida Gwaii will eventually be declared a National Marine Conservation Area in perpetuity*
Adequate collection and processing of samples	*This study was historical (desk-top); there was no new field work (collecting)*
Identification and care of specimens	*Gwaii Haanas is not a repository – we dredged the literature and accessed museum collection databases*
Accessibility of data for wide dissemination	*We are committed to the species data eventually being on the World Wide Web*

[1] New (1998) "Invertebrate surveys for conservation". Oxford University Press, New York

southern Haida Gwaii off the northern British Columbia mainland coast (Figure 1). Gwaii Haanas itself incorporates ≈1,470 km^2 of land, ≈3,400 km^2 of proposed sea space and ≈1,700 km of shoreline. Gwaii Haanas represents the National Marine Conservation Area Natural Regions of Queen Charlotte Islands Shelf to the west, Hecate Strait to the east and borders the Queen Charlotte Sound region to the south (Mercier and Mondor 1995).

Haida Gwaii's west coast is exposed to the full force of the Northeast Pacific's weather. This coast has a limited continental shelf ≈30 km wide off Langara Island narrowing towards the south to ≈5 km wide for much of the west coast of Gwaii Haanas. Seaward of the break in slope, at .200 m depth demarcating the edge of the continental shelf, is a steep continental slope descending to >2500 m depth within 30 km offshore of Gwaii Haanas (Thomson 1989; Barrie and Conway 1996). The east coast of Haida Gwaii faces Hecate Strait, which extends ≈75 km to the northern British Columbia mainland, and is mostly shallower than 150 m (Fedje and Christensen 1999).

Three physiographic regions divide the lands of Haida Gwaii longitudinally in a northwest to southeast orientation (Golumbia 2001). The Queen Charlotte Lowlands is represented on Northeast Graham Island. The Skidegate Plateau and the Windward Queen Charlotte Ranges extend further south and are represented in

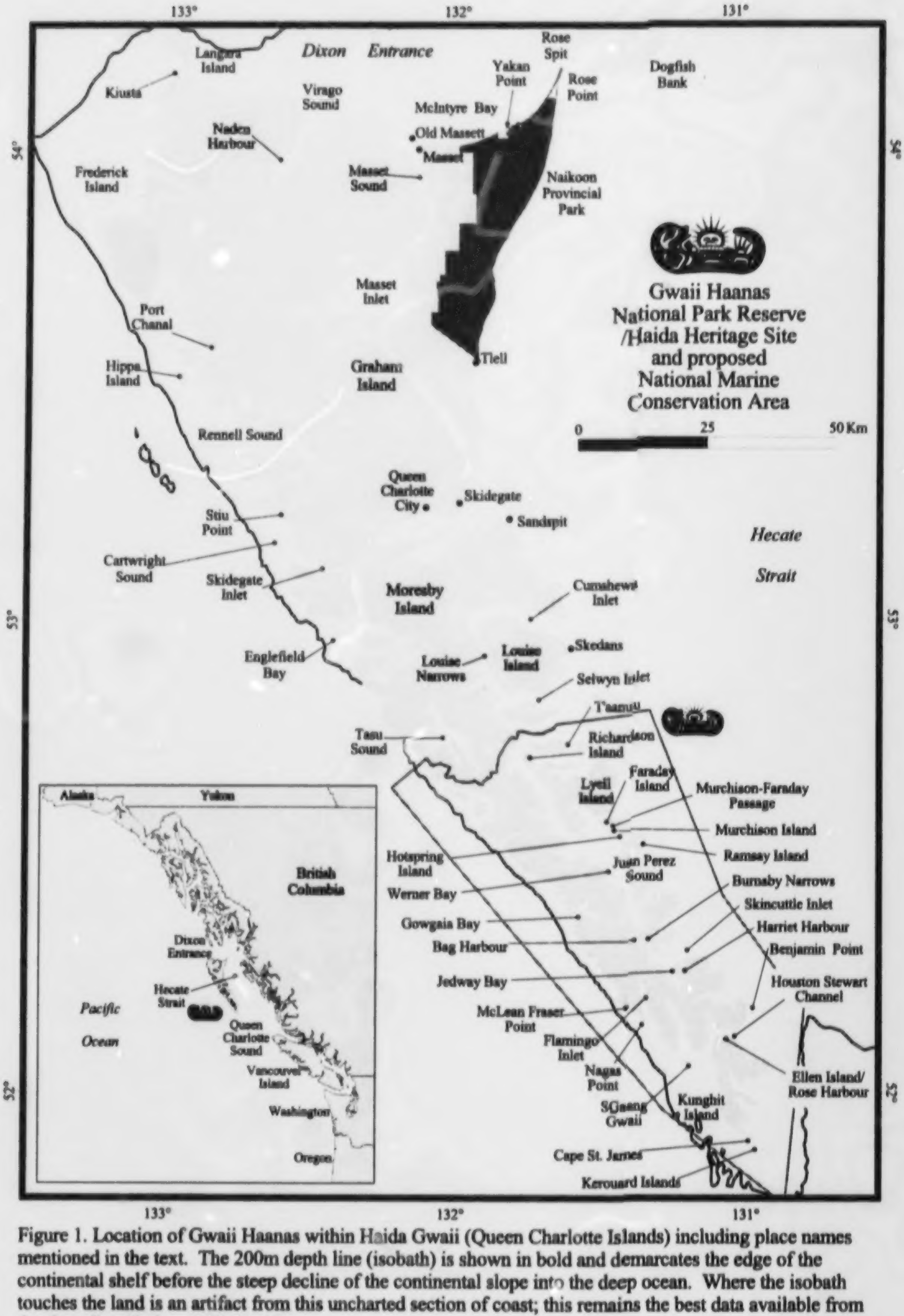

133°
132°
131°
Dixon Entrance
Rose Spit
Yakan Point
Rose Point
Dogfish Bank
Langara Island
Kiusta
Virago Sound
McIntyre Bay
Old Massett
Masset
Naden Harbour
Masset Sound
Frederick Island
Naikoon Provincial Park
54°
Gwaii Haanas National Park Reserve /Haida Heritage Site and proposed National Marine Conservation Area
Masset Inlet
Port Chanal
Tlell
Hippa Island
Graham Island
0
25
50 Km
Rennell Sound
Queen Charlotte City
Skidegate
Sandspit
Stiu Point
Hecate Strait
Cartwright Sound
Skidegate Inlet
Moresby Island
Cumshewa Inlet
53°
Englefield Bay
Louise Narrows
Louise Island
Skedans
Selwyn Inlet
T'aanuu
Tasu Sound
Richardson Island
Lyell Island
Faraday Island
Murchison-Faraday Passage
Murchison Island
Hotspring Island
Ramsay Island
Juan Perez Sound
Werner Bay
Burnaby Narrows
Gowgaia Bay
Skincuttle Inlet
Bag Harbour
Harriet Harbour
Benjamin Point
Jedway Bay
Houston Stewart Channel
McLean Fraser Point
Flamingo Inlet
Ellen Island/ Rose Harbour
Nagas Point
SGaang Gwaii
Kunghit Island
52°
Cape St. James
Kerouard Islands
Alaska
Yukon
British Columbia
Dixon Entrance
Hecate Strait
Pacific Ocean
Queen Charlotte Sound
Vancouver Island
Washington
Oregon

Figure 1. Location of Gwaii Haanas within Haida Gwaii (Queen Charlotte Islands) including place names mentioned in the text. The 200m depth line (isobath) is shown in bold and demarcates the edge of the continental shelf before the steep decline of the continental slope into the deep ocean. Where the isobath touches the land is an artifact from this uncharted section of coast; this remains the best data available from the Canadian Hydrographic Service.

Gwaii Haanas. There are three biogeoclimatic zones in Haida Gwaii (Green and Klinka 1994), keeping in mind that the area is exposed to powerful, saline sea winds and heavy rains. The Coastal Western Hemlock zone is subdivided into two subzones. The Very Wet Hypermaritime Coastal Western Hemlock subzone represents the windward west coast, and is dominated by boggy woodlands. The Wet Hypermaritime Coastal Western Hemlock subzone represents the leeward eastern side of the archipelago and is the typical coastal temperate rainforest dominated by large hemlock, spruce and cedar trees. The Mountain Hemlock and the Alpine Tundra zones are found at higher elevations (550 to 600 m and 650 to 800 m, respectively). Several peaks in the Queen Charlotte Range exceed 1100 m in elevation, although these larger peaks are concentrated on north central Moresby Island and southern Graham Island (T. Golumbia, Gwaii Haanas, *personal communication*).

Gwaii Haanas' coastal zone is a highly incised, mostly rocky (≈75%) shoreline. Less than 10% of the shoreline is sandy and ≈6% is level, estuarine wetlands. The entire shoreline has received preliminary biophysical classification (Harper *et al.* 1994) and is on a GIS platform for our marine knowledge.

This report covers invertebrate species whose adult phases are benthic, pelagic or parasitic (ecto and endo – McDonald 2001). Holoplanktonic invertebrates (species whose lifecycles are entirely planktonic - e.g., Wrobel and Mills 1998) are included, but protozoa and fossil species are not. Planktonic invertebrates certainly warrant their own inventory, which should be strongly linked to the proposed physical oceanography volume in the series. The knowledge of planktonic invertebrates in the Gwaii Haanas area is particularly poor. For example, the overview of pelagic copepods of British Columbia (Gardiner and Szabo 1982) relies almost completely on one paper (Cameron 1957) for the species from the Haida Gwaii region.

By necessity, this report is a compromise in favour of disseminating an overview of a poorly known region rather than an exhaustive taxonomic survey that would require extensive fieldwork and many years of laboratory support. It does not compare, for example, to the thoroughness of the 20-year marine invertebrate survey of the Gulf of St. Lawrence region (Brunel *et al.*1998) or the 14-volume benthic fauna series on the Santa Barbara Channel region in California issued by the Santa Barbara Museum of Natural History. This report is, therefore, a first step towards a marine invertebrate species biodiversity baseline of the Haida Gwaii region. It is also one of the few comprehensive marine invertebrate surveys for a national park in North America. In a survey of 252 U.S. National Parks and National Monuments, Stohlgren *et al.* (1994) reported that few parks had complete invertebrate inventories.

Our intent is to provide the following:

- guidance on what is known about marine invertebrates of the region;
- some synthesis into an integrated overview relevant to conservation; and
- identification of noteworthy knowledge gaps.

We hope that this volume will function as a technical reference to assist with invertebrate issues in forthcoming public consultations on declaration of the proposed Gwaii Haanas National Marine Conservation Area. We try to clarify the complexities of marine invertebrate-related issues and their attendant management concerns for a wide readership in an accessible and technically sound document.

PARKS CANADA'S MARINE INVENTORY HISTORY

It is relevant to review Parks Canada's history of executing marine inventories. In the 1970s, a national Parks Canada natural resource inventory program was managed out of the national office, and later dispersed to regional offices. As part of this program, some marine resource inventories were done. The first were for Kouchibouguac National Park, New Brunswick (Partinquin and Butler 1976; Greenwood and Davidson-Arnott 1977) and Pacific Rim National Park, British Columbia - after the latter's establishment in 1970. The Kouchibouguac projects were subsumed into a Resource Description and Analysis for the park (Beach 1988). For Pacific Rim National Park, there was a Parks Canada contract to Fisheries and Oceans Canada (DFO) at the Pacific Biological Station, Nanaimo that enabled collaboration between a contractor (Lee) and a DFO research scientist (Bourne). The resulting six reports yielded over 1,300 published pages of marine inventory (Lee and Bourne 1973, 1976, 1977, 1978, 1979; Lee *et al.* 1982). Under an independent Quebec Region (federal-provincial) program in the late 1980s and early 1990s, a series of inventory studies were executed for Saguenay-St.Lawrence Marine Park (Anonymous 1995).

Concerning the Pacific coast, in the initial Pacific Rim National Park report, Lee and Bourne (1973) reviewed the history on marine biological research in the region and concluded; *"A thorough knowledge of the marine flora and fauna in these habitats is necessary to preserve this valuable resource."* They urged the park to undertake taxonomic, systematic, distribution and ecological work (e.g., a *"habitat-species checklist"*) to *"provide a sound knowledgeable basis for information of management policies."* The science was to enable *"optimum utilization and preservation"* in preparation for likely increasing visitor effects that they correctly predicted the park would experience in the future. Essentially, Pacific Rim National Park's values underlying their inventory are similar to ours for Gwaii Haanas.

Fieldwork on Pacific Rim National Park's *"biophysical resource inventory"* started in 1975 and the series of reports focused on defining intertidal and shallow (diving depth) subtidal habitat types, faunal and floral surveys and visitor impact studies (Lee and Bourne 1976, 1977, 1978, 1979). Habitat types were split into intertidal or subtidal, then each according to exposure (exposed/semi-exposed/sheltered), then each of these according to three or four substrate types (mud/sand/gravel/rock). These quantitative studies were divided according to the park's three discrete units: Long Beach, Broken Group Islands and West Coast Trail. Further, some data collection methods varied according to unit; making park-wide integration difficult. The visitor impact work focused mainly on shellfish collection in the (most visited) Long Beach unit. The final report (Lee *et al.* 1982 – not issued as a DFO report) synthesized the detailed descriptions of biota and their habitat types into a biophysical classification system yielding map unit descriptions and biophysical maps. Mapping scales varied according to park unit (1:25,000 and 1:12,500). Also in Pacific Rim National Park was Parks Canada's first attempt at marine plant inventory and monitoring (Druehl and Elliott 1996) as reviewed in Sloan and Bartier (2000).

The Pacific Rim National Park inventory remains partitioned according to park unit, is not much used in current park operations, has not been put into an electronic format and, therefore, is not represented in the park's current GIS. There is now a Pacific Rim National Park proposal for a new and integrated (all units: land/ coast/sea), GIS-based biophysical inventory. Nonetheless, some of these historical data are likely worthy of being digitized into their data system/GIS and should not be lost. For example, early data could provide a baseline useful, at some locations, for long-term monitoring of population-ecosystem status. An advantage for Pacific Rim National Park is that (university-managed) Bamfield Marine Station, which is within the park's region, has also completed inventories that could contribute.

Gwaii Haanas has been lucky in comparison as we had the commitment to GIS in hand while compiling our inventories whereas the early Pacific Rim National Park work pre-dates development of GIS. Pacific Rim National Park may have to retrofit some old data and/or gather inventory data 30 years after its establishment. This situation underscores a problem in Parks Canada with the fate of historical science data (Parks Canada Agency 2000).

METHODS

"The provision of accurate and rapid identification of specimens from every possible ecosystem has become an urgent requirement ..." (Brinkhurst 1985)

"... documenting species is one thing, while knowing something about their position in the ecosystem is another." (Tunnicliffe 1993)

"Although by far the greatest part of British Columbia's biodiversity is made up of invertebrates, they are the least known of any major biological group" (Scudder 1996)

"...most animals are invertebrates, and most conservation managers and practitioners know very little about their biology or how to study and survey them adequately in the field." (New 1998)

"The first step in biodiversity management is to identify what is there, where it is, and provide comparative data for evaluation and prioritization of conservation effort. Advice to management must recognise limitations of current knowledge but use all available data." (Costello 1998)

"......conservation biologists often require copious quantities of data concerning the distribution of species in order to establish conservation priorities." (Snow and Keating 1999)

"Species are the most practical and widely applicable measure of biodiversity. They are the common currency for marine biodiversity research and management, and the only measure of biodiversity with a well-established standardized code of nomenclature. Species names (taxonomy) are thus at the foundation of quality control in biological studies." (Costello 2000)

"Systematics research provides the most basic information needed to place a value on natural resources. Its strength lies in linking the data available from widely dispersed resources, and making then accessible through new and developing informatics technologies."

".... there is a need to ensure that Canada has an appropriate number of systematics experts; that comprehensive biodiversity information is easily accessible; and that scientists, decision makers and the public understand the utility of this field of research."

(both Industry Canada - IC 2000)

"Marine taxonomy and systematics must also be revitalized." (Hixon *et al.* 2001)

INFORMATION TECHNOLOGY, SYSTEMATICS, TAXONOMY AND BIODIVERSITY

In introducing the methods, let us pause, define terms relevant to assessing species biodiversity and reflect on the great influence of information technology on conservation. This inventory comes at a time when we must take stock of the ecosystems and their components to enable marine area conservation. Yet our capacity to describe species biodiversity is seriously underdeveloped. On the other hand, the advent of computer technology (including GIS and the internet) and sensing technologies (Malakoff 2000) now enables handling huge quantities of data that will underpin modern marine conservation. Concerning biological databases and the burgeoning information technology, the U.S. National Science Foundation has declared that: *"Much of the biology of tomorrow will arise through discovery based on information contained in community-accessible databases."* The Foundation claims that the future of biological research will depend on deposits into, and uses of, stored information on-line. Information technology is, therefore, revolutionizing conservation biology, and we have lots of historical data to get started!

Systematics was defined by Simpson (1961) as *"... the scientific study of the kinds and diversity of organisms and of any and all relationships among them."* These relationships can include ecological, behavioural and phylogenetic. Taxonomy, often lumped by non-biologists with systematics, was defined by Mayer (1969) as *"... the theory and practice of classifying organisms."* Besides assessing the inferred relationships and similarities between organisms, taxonomy also involves rules and procedures for describing and naming organisms. The classification of organisms into hierarchies (e.g., among invertebrates, starting with phylum and ending with species) is in the realm of systematics, while the fine detail of organism description and naming is in the realm of taxonomy.

By the mid-20th century it was clear that there was a grave shortage of taxonomists (Hedgpeth *et al.* 1953) and the situation remains poor globally (NRC 2001). The paradox of this situation was not lost on New (1995), in that growing concern over invertebrate biodiversity loss increases the need for species inventory, yet our human resources to acquire such fundamental knowledge are decreasing. Industry Canada (IC 2000) summarised the situation as follows: *"The continuing worldwide decline of expertise in systematics, and especially taxonomy, is an issue or concern within the biological research community."* This skill shortage is also keenly felt in British Columbia (Lambert 1994). As well, the U.S. National Research Council (NRC 1995) called for *".... reinvigorating the fields of marine taxonomy and systematics"* in response to the pressing need for better marine biodiversity information.

There is a near-term need to counteract this taxonomic skills bottleneck. Examples exist from terrestrial invertebrate surveys where non-specialists are used in different ways. Oliver and Beattie (1996) described rapid rough-sorting of specimens into *"morphospecies"* to assist specialist taxonomists that can more rapidly focus at the species level. Basset *et al.* (2000) discuss the training of *"parataxonomists"* working on insects in developing countries that blend collecting, sorting, collection care and inclusion of traditional indigenous forest knowledge to compliment specialist taxonomists operating in developed countries. Time is crucial as high species and habitat loss rates compel near-term fixes to facilitate gathering biodiversity information despite shortages of taxonomists.

International cooperation in systematics and biodiversity is vital. Since 1995, the U.S.-based Association of Systematics Collections (http://www.ascoll.org/) has linked the collections resources of institutions, their human resources and systematics research *"for the benefit of science and society."* The Association developed databases to facilitate information sharing including cooperating in the Integrated Taxonomic Information System (ITIS) partnership. The ITIS is the first comprehensive, standardized reference on the World Wide Web for on-line biological names of North American fauna and flora. The Association also supports directories of taxonomists and of natural history collections and their in-house databases. Most Canadian museums and similar institutions cooperate in the Association.

The concept for ITIS (originally the Interagency Taxonomic Information System) began in ≈1992 with discussions between the U.S. Environmental Protection Service, the National Oceanographic Data Centre and the U.S. Geological Survey. The ITIS database became operational by1997 and more U.S. agencies were added. Now, the ITIS is a dynamic international checklist supported by government agencies of Canada and Mexico as well as the U.S. and maintained by a network of >1,000 taxonomist members of the Association of Systematic Collections. The ITIS is accessible in Canada (http://res.agr.ca/itis) and the U.S. (http://www.itis.usda.gov/plantproj/itis/index.html).

The ITIS conforms with the *International Codes of Botanical* and *Zoological Nomenclature*. This is critical. The species name is the common information currency between the ITIS and our Haida Gwaii database. The ITIS will long be a work-in-progress because it lags behind the publication of new information and because most of the world's invertebrate species are yet to be described. The ITIS assigns a unique code (*"Taxonomic Serial Number"*) to each taxon and all attendant systematic levels up to Kingdom. These codes can be downloaded on demand because scientists have the species names in common. Such codes will likely be important in the future for large-scale database manipulations and regional database comparisons. The ITIS also includes, for all systematic levels, taxonomic authorities (the initial namer[s] of each species) and synonyms (different names for the same species) and data quality indicators. The synonym links are important because they assist tracing name changes over time. Central to the data quality process is peer review prior to incorporation into ITIS, and periodical review thereafter. The ITIS, therefore, facilitates international sharing, transfer and comparison of information. This is important for national agencies such as Parks Canada when cooperating with international programs and global issues of information sharing in support of biodiversity knowledge.

On a global scale, informatics technologies are enabling projects to record Earth's 1.5-2 million known species. In 2000, the ALL Species project to catalogue every living species within 25 years (at an estimated cost of $1 to $3 billion U.S.!) was launched by the NGO *All Species Foundation* (http://www.all-species.org). As well, there are other projects include the following:

- Species 2000 (http://www.species2000.org) launched in 1996;
- International Plant Name Index (IPNI) (http://www.ipni.org/) for vascular plants; and
- Index to Organism Names (http://www.york.biosis.org/) for all other species not covered by IPNI.

At this early stage, S.D. Blum's overview of biodiversity informatics on the ALL Species web page recounts replication and lack of functional integration among these projects that likely will be resolved in time.

On a global marine scale, the United Nations Education, Scientific and Cultural Organization (UNESCO) and the International Oceanographic Commission (IOC) are preparing a *UNESCO-IOC Register of Marine Species* with which regional and national lists can be cross-referenced (Costello 2000): (http://www.eti2.eti.uva.nl/-database/urmo). As well, there is the *Census of Marine Life*, funded by the U.S. Alfred P. Sloan Foundation since 1997, to enumerate and map all marine species (Malakoff 2000).

Canadian science policy makers are concerned about this nation's situation, as revealed by the Industry Canada statements cited above (IC 2000). These statements are significant as Industry Canada is the nation's senior science policy forum with the mandate for coordinating federal interdepartmental science and technology policy. Their recent report has a section; "Systematics Research and Bio-Informatics" devoted to this key issue (IC 2000, p. 34).

Canada is a signatory to the United Nations' *International Convention on Biological Diversity* (arising from the Rio "Earth Summit" of 1992) that sponsors the Global Taxonomy Initiative promoting building taxonomic capacity world-wide and the Global Biodiversity Information Facility promoting global biodiversity information sharing. The Global Biodiversity Information Facility was proposed by the Biodiversity Informatics Working Group of the Paris-based Organization for Economic Co-operation and Development to promote international collaboration as humanity confronts species extinctions and ecosystem damage world-wide.

In 1998, Canada established the Federal Biosystematics Partnership (Environment Canada, Fisheries and Oceans Canada, Natural Resources Canada, Agriculture and Agri-Food Canada - chaired by the Canadian Museum of Nature) to pursue the following national initiatives:

- facilitate a systematics needs assessment;
- support the ITIS; and
- position Canada within the Global Biodiversity Information Facility.

Parks Canada joined the Federal Biosystematics Partnership in 2001.

The federal biodiversity science structure in Canada is complex and evolving rapidly. A brief overview of linked federal - regional initiatives is warranted, along with connections to international entities. For example, the Canadian Museum of Nature houses the Canadian Centre for Biodiversity, cooperates in Biota of Canada Information Network and coordinates seven facilities nation-wide in a supplemental National Science and Engineering Research Council grants program to encourage graduate student systematics studies. That is just one federal agency within a burgeoning federal network of biodiversity-based initiatives.

At the regional level, there are now seven Conservation Data Centre or equivalent entities (six provinces, including British Columbia, and the Atlantic region), one under development for the Yukon and others planned for the remaining territories. The focus to date in the British Columbia centre (under the provincial Ministry of Environment, Lands and Parks [http://www.elp.gov.bc.ca/rib/wis/cdc/]) has largely been terrestrial. An initial database of ≈150 rare and endangered marine species was developed (Austin *et al.* 1997), for which there is a marine invertebrate component (Austin 2000). Conservation Data Centres develop regional species lists and information on rarity, conservation status (provincial and global) and location of rare and endangered species. For example, the British Columbia Centre ranks each species (red = *"extirpated – endangered - threatened"* / blue = *"vulnerable"* / yellow = *"not at risk"*), tracks their status and issues reports on demand. Although funded provincially, these centres cooperate in an international network of the Association for Biodiversity Information (http://www.abi.org) that supports standardized data formats enabling international data sharing. The Canadian non-governmental organization linking Conservation Data Centres with federal biodiversity initiatives is the Association for Biodiversity Information Canada (http://www.abi-canada.ca/) in Ottawa. The Association facilitates regional-federal biodiversity cooperation and information exchange. For example, our regional marine invertebrate inventory will eventually be shared with the provincial Conservation Data Centre in Victoria and linked nationally and internationally via the Association for Biodiversity Information Canada.

Concerning Canadian marine biodiversity, DFO's Bedford Institute of Oceanography, Dartmouth, Nova Scotia established the nation's first Centre for Marine Biodiversity in 2000. The first national marine biodiversity workshop (in Dartmouth) is scheduled for February 2002 and will include international and Canadian Atlantic, Arctic and Pacific scientists. The workshop organisers hope to achieve the following:

- review current knowledge and data gaps on national marine biodiversity;
- evaluate current models used to explore trophic and species dynamics in Canadian marine ecosystems;
- discuss maintenance of marine biodiversity at various levels (species to ecosystem); and
- plan for compilation of the principles to guide Canadian marine biodiversity conservation.

We have provided detailed information on biodiversity initiatives to put into context the purpose and fate of our Haida Gwaii species biodiversity data. There are many recent initiatives dealing with the world-wide problems in biodiversity losses and ecosystem damage that will influence what Canada is about to begin doing. Places such as Gwaii Haanas will become key regional reference locations for biodiversity information manifesting Canada's contribution to world environmental knowledge. In summary, therefore, this is a historic time of:

- rapid expansion of regional, national and international cooperation on marine biodiversity information gathering that is increasing awareness of the need for more systematics and taxonomy to support conservation; and
- revolutionary development of computer-based tools to handle and exchange biological information.

INFORMATION SOURCES AND CAVEATS ON INFORMATION QUALITY

We report on all species of the Haida Gwaii region from any published source, accessible collection and unpublished observations from scientists. Species usually have a two-part Latin name. The first is the *genus* (a unique name) to which the species belongs. A genus can have a number of species within it. The second is the *specific epithet* or name of the species. The specific epithet is not necessarily a unique word, but taken together with the genus name becomes part of a unique couplet. Some species have been divided into subspecies and these are included in the database. Sometimes, specimens were not identified to species level. We have included these where they have been identified to at least the family or genus level. These may be either rough field identifications or incompletely identified (not to species level) materials in museums.

Our report represents ≈120 years of science collecting and research from this region. The main marine invertebrate taxonomic sources for the British Columbia area of the Northeast Pacific are Austin (1985) and Kozloff (1996). These are the most recent checklists and collectively they cover ≈80% of the taxa in this report. Between the two, we gave priority to the most recent. For taxa not found in Austin or Kozloff, the ITIS was used. For some parasitic taxa, we used the European Register of Marine Species (Costello 2000 - http://www.erms.biol.soton.ac.uk). As well, many additions and updates to our species list were made based on literature either omitted from or published since Austin (1985) and Kozloff (1996). For example, we used recent monographs on particular groups such as on polychaetes (Rouse and Fauchauld 1997), bivalves (Coan *et al.* 2000), amphipods (Bousfield 2001), sea stars

(Lambert 2000) and sea cucumbers (Lambert 1997). Another recent change reflected in the database is the inclusion of the parasitic phylum Myxozoa into the phylum Cnidaria (Siddall *et al.* 1995). Some taxa had unique documentation because of the nature of their description from this region, and they are individually cited. Finally, the original data from some published work from this region have been lost.

Our marine invertebrate species data quality criteria can be ranked as follows:

1. species for which the "type"* specimen(s) come from the Haida Gwaii region;
2. species for which there are other museum specimens;
3. species mentioned in internationally peer-reviewed and historical publications;
4. species mentioned in "grey" literature reports and unpublished surveys; and
5. species observations for which there are known or suspected problems.

* the specimen(s) from which a new species is described (Jeffrey 1973)

Within the grey literature, the expertise of investigators determines data quality. If taxonomic specialists were engaged, this increases the report's reliability.

Unlike the marine plant inventory (Sloan and Bartier 2000), in which there were detailed regional starting points (e.g., Hawkes *et al.* 1978; Scagel *et al.* 1993), the invertebrates have a more scattered science history as recounted in the history section later. In our search, we first accounted for all the Parks Canada-funded information. Secondly, we searched the literature (and internet) for Haida Gwaii region marine biological expeditions by Canadian and foreign museums, universities and agencies. For print materials, we started with W.C. Austin's library and spread outward. The most important Canadian agency working on the region's marine invertebrates has been Fisheries and Oceans Canada (DFO). Whereas, for example, research on this region's marine geology, stimulated by its mineral and hydrocarbon potential, has been investigated by the Geological Survey of Canada, Natural Resources Canada [NRCan] (Woodsworth 1991).

The 21 North American museums and institutions contacted for marine invertebrate material from the Haida Gwaii region are listed in Appendix A. Of these, 16 had Haida Gwaii material. Eight overseas museums known to have material from our region are also listed. These were contacted by internet, but our enquiries yielded no species as their Haida Gwaii records were not available electronically. This is particularly regrettable as the Russian museums have important deep-sea materials including type specimens. The 12,933 records retrieved and the methods of our inquiry are listed according to North American institution in Table 2. The largest holdings of regional material are, as expected, in Canadian museums. As their collections were reviewed on service contracts to Gwaii Haanas, these collection data are the best we have. This is, however, still not likely complete as these museums each have unquantified amounts of unsorted and/or unidentified material from the Haida Gwaii region. For other institutions, such as the U.S. National Museum of Natural History (Smithsonian Institution, Washington, D.C.), there is likely more identified material not yet entered into their databases as well as unsorted and/or unidentified material in storage. In summary, our survey is not complete as there are Haida Gwaii region species records in North American and overseas institutions that are not yet available electronically. But, at least we know where they are for future reference.

Table 2. Collections of marine invertebrates from the Haida Gwaii region listed according to institution with information on our methods of data collection.

Collection[1]	Species		No. of undetermined records[3]	Methods of Data Collection			
	No. of records[2]	No. of species		Internet Search	Service Contract	Response to enquiry	Literature Search
RBCM	3979	951	≈600	X	X	NA	X
CMN	2156	677	≈220		X	NA	X
ROM	5895	436	≈2100		X	NA	X
USNM	423	227	ND	X		X	X
LACM	297	107	ND	X		X	X
CAS	138	75	ND			X	X
YPM	17	13	ND	X			X
MCZ	11	11	ND	X			X
ERIC	4	4	ND				X
ANSP	2	2	ND	X			X
FMNH	2	1	ND	X			X
FLMNH	1	1	ND	X			
SU	1	1	ND				X
NMNZ	1	1	ND				X
OSU	1	1	ND				X
Russia	4	4	ND				X

[1] RBCM = Royal British Columbia Museum; CMN = Canadian Museum of Nature; ROM = Royal Ontario Museum; USNM = U.S. National Museum of Natural History; LACM = Los Angeles County Museum of Natural History; CAS = California Academy of Sciences; YPM = Peabody Museum, Yale University; MCZ = Museum of Comparative Zoology, Harvard University; ERIC = Agricultural Canada Insect Collection; ANSP = Academy of Natural Sciences of Philadelphia; FMNH = Field Museum of Natural History; FLMNH = Florida Museum of Natural History; SU = Stanford University; NMNZ = National Museum of New Zealand; OSU = Oregon State University; Russia = unknown collection in Russia.

[2] a record can be based on anything from a body part of an identified species to a group of sorted and identified individuals

[3] these records have not been identified to the species level and could be individuals to unsorted sample lots

NA = not applicable

ND = no data

In the Haida Gwaii species compilation we encountered many anomalies. Therefore, we describe the caveats for, and limitations of, our invertebrate database. Modifications to the database structure used for marine plants in Sloan and Bartier (2000) were required for the invertebrates due to more complex and varied information as follows:

- there were many more types of information sources;
- the range of invertebrate habitats is much more diverse (estuarine to deep-sea);
- the sampling methodologies for invertebrates are more varied;
- a higher proportion of the invertebrate literature is pre-1950s compared to the plant literature (most was post-1950s) and this led to relatively more incomplete identifications and other data problems such as incomplete information on sampling location (first two dimensions), depth (third dimension), date (fourth dimension) method and collector(s) - making it difficult to ensure that all observations are accounted for, and, only once;
- any sampling location could experience different sampling methods, multiple sampling depths and over a greater range of time; and
- one publication can report on material from multiple samplings over time.

Examples of possible gaps in our coverage may include missed Ph.D. dissertations, which often lead to many follow-on materials, missed recent publications and missed government documents, especially those of the United States.

Incorrect Identifications

This is likely common, especially in non-specialist reports from the region. Misidentification can even occur in accessioned museum collections after acquisition of whole, but unreviewed, collections. For example, the Royal British Columbia Museum (RBCM) acquired Parks Canada's collections from surveys of Burnaby and Murchison Faraday Passes (TEC/HFP 1993, 1994). Among the specimens were the snails *Ceratostoma inornatum* and *Ilyanassa obsoleta*, both of which were significant range extensions for these species. Upon re-examination, however, the specimens were identified as *Trophonopsis orpheus* and either *Nucella emarginata* or *Nucella lima* respectively (P. Lambert, RBCM, *personal communication*), all of which are known from Haida Gwaii. In another example, Reimchen (1984) lists the unusual echiuroid worm *Urechis caupo* from the Lyell Island area. Yet, this species is not known from north of Oregon (Austin 1985; Kozloff 1996). No specimen from this region is in any collection, so this significant range extension cannot be verified. Only thorough review by taxonomic specialists for each group will provide reliable identification. That is why the Gulf of St. Lawrence invertebrate survey took ≈20 years to draw (globally) upon the experts to review specific organism groups (Brunel *et al.* 1998). Sadly, few invertebrate collections from Haida Gwaii have experienced such detailed taxonomic scrutiny.

Disconnected and Lost Species Names

Austin (1985) was our main reference for synonyms (different names for the same species). However, except for those with specialized knowledge, some names in publications before the 1950s appear disconnected with modern names. This is because full lists of synonyms (with all synonyms indexed) are not given in most publications. Such situations required intermediate references before they could be appropriately placed in the database. Table 3 lists examples of presently accepted species names and their connections through synonyms over time. We use

Table 3. Examples of changing names of two mollusk species over time that can cause disconnection in species databases. Museums are listed where that particular name occurs in their current collection database.

Presently Accepted Species Name	Synonyms	Reference and Museum
Tegula pulligo[1] (Gmelin, 1791)	*Phorcus pulligo* (Martyn, 1784)	Newcombe (1891), Taylor (1895); CMN
	Gibbula pulligo (Martyn, 1784)	Whiteaves (1880)
	Tegula pulligo taylori Oldroyd, 1922	Clemens (1933)
Clinocardium blandum[2] (Gould, 1850)	*Cardium blandum* Gould, 1850	Whiteaves (1880)
	Clinocardium fucanum (Dall, 1907)	Burd and Brinkhurst (1987); ROM
	Cardium fucanum Dall, 1907	Burd and Brinkhurst (1987); RBCM

1 in Kozloff (1996)
2 in Coan *et al.* (2000)
CMN = Canadian Museum of Nature
ROM = Royal Ontario Museum
RBCM = Royal British Columbia Museum

examples of a snail (genus *Tegula*) and a cockle (genus *Clinocardium*). We anticipate that not all synonyms have been corrected out of our database.

For a few invertebrate species first described from Haida Gwaii we were unable to connect the early work with contemporary literature or databases (Table 4). This could be because populations of these species were not recorded again from the region or we have simply lost track of their synonyms. If the intertidal beetles were named, but not described, their names are *nomen nuda* and cannot be used under the *International Code of Zoological Nomenclature*. Finally, there can also odd situations that cause confusion such as two families (among the sponges and gastropods) that have the same name (Family Clionidae).

Table 4. Marine invertebrate species names first mentioned from Haida Gwaii but subsequently not found in the contemporary literature or in databases.

Species	Notes
Schizoporella maculosa *Tubulipora dawsoni* *Porella argentea* Bryozoans	collected by Dawson (1880), but not mentioned again after being described by Hincks (1884)
Mumiola tenuis *Odostomia inflecta* Snails	reported first by C.F. Newcombe from Cumshewa Inlet, but not mentioned again after being described by Dall (1897)
Lathrimaeum keeni *Bryobiotos keeni* Intertidal Beetles	listed as new species from Masset-area beaches by Keen (1895); they were named, but not actually described, as intended, by A. Fauvel

Errors of Sample Location

Errors associated with sample locations are not uncommon. For example, there are two Moresby Islands in British Columbia. Other, more complicated situations occur such as the Hecate Strait Dungeness crab diet studies (Bernard 1979, 1981) that yielded some unique species records for this region. Here, the problem was that the species occurrences were not linked to individual samples among the 53 trawl sites. In this case, we used the approximate mid-point within the geographic range of all the sample locations for all the species records. Other instances are incorrect location names: Alert Bay, Queen Charlotte

Islands (Bartsch 1912) and Cumshewa Inlet, Vancouver Island (Bartsch 1916). There are also location misspellings such as La Paz Bay for Lepas Bay (Coan 1971).

Missing Data and Specimens

There were lost data underlying some published species information. For example, Bernard (1967 a) created an early (punch-card) computer database for the dredging survey mollusc data at the Pacific Biological Station (DFO). These historical data have, apparently, been lost (N. Bourne, DFO, *personal communication*). Other examples are from papers including regional marine invertebrates for which raw sample location data are cited as lodged with Depository of Unpublished Data, Canadian Institute of Scientific and Technical Information (CISTI), National Research Council, Ottawa (Baker 1982; Coates 1983; Kirkendale and Lambert 1995). However, these data were not present in CISTI files when requested by us.

Specimens also go missing. For example, in the benchmark review of Northeast Pacific bivalves, Coan *et al.* (2000) report the deep jewelbox oyster *Pseudochama granti*, citing Parks Canada material from Murchison Faraday Passage (TEC/HFP 1994). Yet, there is no specimen to verify this. In other cases, species are listed from this region, such as the jellyfish fauna by Bigelow (1913), but the specimens become less traceable after they were dispersed to various museums.

DATABASE STRUCTURE

The database structure was expanded from that used for the marine plants (Sloan and Bartier 2000). Our structure, with additions, was adapted from the structure developed by the Association of Systematic Collections and ITIS. We do observe the taxonomic conventions in ITIS. We list the observations from the Haida Gwaii region in space (latitude/longitude/depth) and time. To enable further inquiry, we link the species with the relevant literature, provide the higher systematic affiliations to assist grouping into related units and identify those observations based on specimens in collections. We also include Haida words for invertebrates as a first step towards linking traditional Aboriginal knowledge into our information system.

Illustrated in Figure 2 is a schematic diagram of an overall database structure showing relationships between tables of elements (technical information types compiled into tables) suitable for a long-term, ecosystem-based regional knowledge framework. This is a work-in-progress. Socioeconomic elements, although important, are not included at this time. The relationships in Figure 2 are either mandatory or optional. For example, an *observation* must come from a *site*, but an *observation* may, or may not, be linked to one or more *specimens* because not all *observations* are backed by collection *specimens*. Relationships are also either one-to-one (1:1), one-to-many (1:N) or many-to-many (N:M). For example, for each *site* in time and space, there is only one set of *physical properties* (1:1); one *site* can have many *observations* (1:N); and one site can be referenced by many sources and one *source* can include many *sites* (N:M).

The elements, each unique, are defined as follows:

Sources – document citations or museum collections
Sites – latitude, longitude, depth, date
Observations – unique combinations of site and taxonomic unit
Specimens – specimens in collections
Haida Names – names of species (or species groups) sanctioned by the Skidegate Haida

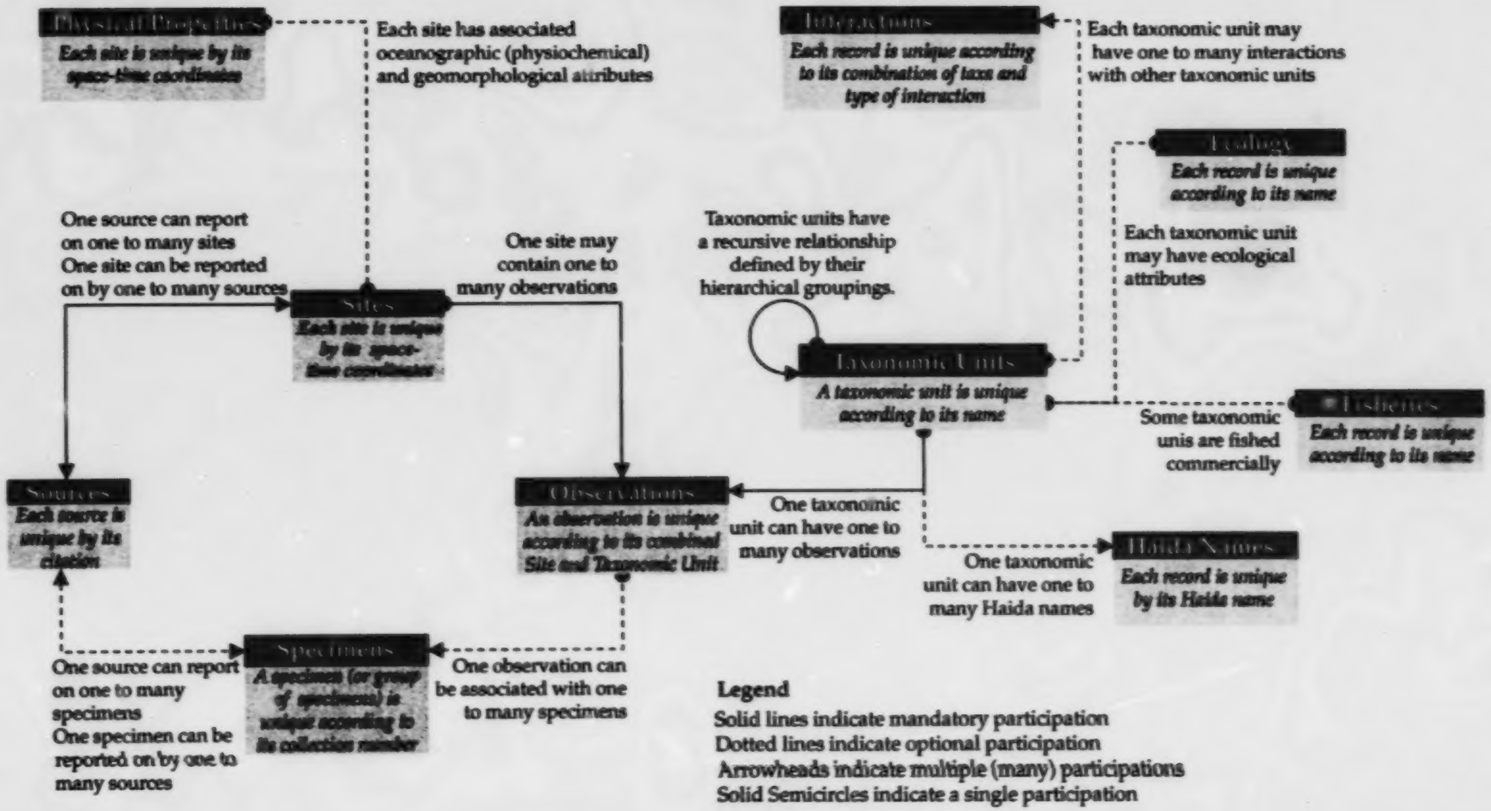

Physical Properties
Each site is unique by its space-time coordinates
Each site has associated oceanographic (physiochemical) and geomorphological attributes
One source can report on one to many sites
One site can be reported on by one to many sources
Sites
Each site is unique by its space-time coordinates
One site may contain one to many observations
Sources
Each source is unique by its citation
Observations
An observation is unique according to its combined Site and Taxonomic Unit
Specimens
A specimen (or group of specimens) is unique according to its collection number
One source can report on one to many specimens
One specimen can be reported on by one to many sources
One observation can be associated with one to many specimens
Interactions
Each record is unique according to its combination of taxa and type of interaction
Each taxonomic unit may have one to many interactions with other taxonomic units
Ecology
Each record is unique according to its name
Each taxonomic unit may have ecological attributes
Taxonomic units have a recursive relationship defined by their hierarchical groupings.
Taxonomic Units
A taxonomic unit is unique according to its name
Fisheries
Each record is unique according to its name
Some taxonomic unis are fished commercially
One taxonomic unit can have one to many observations
One taxonomic unit can have one to many Haida names
Haida Names
Each record is unique by its Haida name
Legend
Solid lines indicate mandatory participation
Dotted lines indicate optional participation
Arrowheads indicate multiple (many) participations
Solid Semicircles indicate a single participation

Figure 2. Schematic diagram of an overall database structure showing all the relationships between the database element tables (information types).

Language Authority, Skidegate Haida Immersion Program (SHIP)
Taxonomic Units – a taxon consistent with the *International Code of Zoological Nomenclature* (a taxon here is a species name or an identified entity to the genus or family level); ideally, each taxon is unique, however it is possible for names at the family level to be redundant

These elements are shared in common with our database in its currently working form as illustrated in Figure 3. However, there are other elements in Figure 2 that are not yet ready for inclusion in our working database as follows:

Interactions – trophic (energy) and/or nutrient flows between different *taxonomic units*
Ecology – ecological attributes of *taxonomic units*, e.g., pelagic, parasitic
Physical Properties – oceanographic or geomorphological data on *sites*
Fisheries – target species or species groups (a *taxonomic unit* could be one species or a group such as the family Pandalidae comprising the trawled shrimp species), also attributes of gear type or fishing season. Spatial fisheries information such as catch according to area or area closures do not fit in the database and warrant separate GIS layers. In the future, these four additional elements will enhance our database structure by incorporating broader ecosystem and fisheries properties.

Illustrated in Figure 3 is a schematic diagram of the actual database structure we used with the attendant relationships between elements. It is a subset of Figure 2. It's tables of elements are the same with the exception of our treatment of *Taxonomic Units*. Further, not all relationships in Figure 2 were employed in Figure 3. The *Taxonomic Units* element in Figure 2 is one table in which the recursive relationship (of self-linked entities) is used for

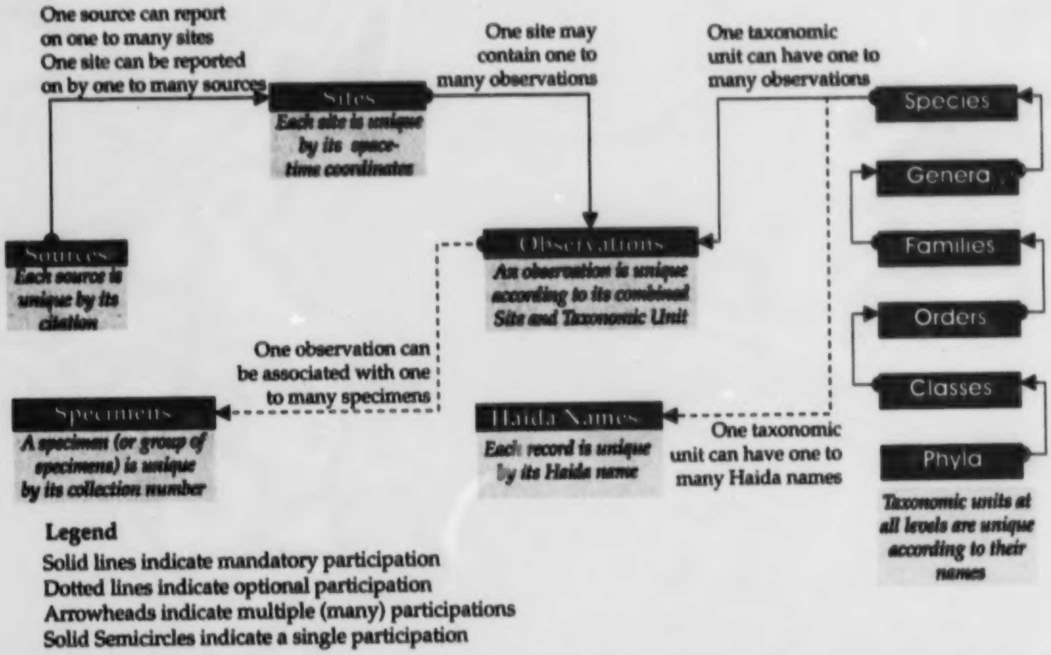

One source can report on one to many sites
One site can be reported on by one to many sources
Sites
Each site is unique by its space-time coordinates
One site may contain one to many observations
One taxonomic unit can have one to many observations
Species
Genera
Families
Orders
Classes
Phyla
Taxonomic units at all levels are unique according to their names
Sources
Each source is unique by its citation
Observations
An observation is unique according to its combined Site and Taxonomic Unit
One observation can be associated with one to many specimens
Specimens
A specimen (or group of specimens) is unique by its collection number
Haida Names
Each record is unique by its Haida name
One taxonomic unit can have one to many Haida names
Legend
Solid lines indicate mandatory participation
Dotted lines indicate optional participation
Arrowheads indicate multiple (many) participations
Solid Semicircles indicate a single participation

Figure 3. Schematic diagram of the actual database structure we used to accommodate the relationships between the element tables (information types).

computational efficiency of large datasets such as one-time correcting. In Figure 3, this is expanded into six hierarchical tables because it is more intuitive for biologists. This expansion, however, introduces redundancy and a potential for multiple corrections for one change such as respelling an intermediate level such as Superorder or Subfamily. Other workers also prefer the expanded format compared to the recursive format as it facilitates biologists' thinking about taxonomic and geographic information and aids preparation of text files for sharing (http://viceroy.eeb.uconn.edu/Biota). Further, the multiple tables can be handled by Microsoft Access© software. More specialized software is needed for collapsing the taxonomic hierarchy into one recursive table. At this time, our database is still small enough for this multiple-table treatment. As more data are added we may put the multiple tables into a recursive taxonomic units table. The attributes and their properties for the elements tables in Figure 3 are listed in Appendix B. This listing of attributes reveals our thinking on properties defining the elements in the working database's current form.

Quality assurance of this database was through both automated methods and hand-checking the *sources*. Examples of automated checking include the "Reliability" attribute of the *Observations* element table in Appendix B, that is, values outside the allowable range of 1 to 5 were excluded; or that no genus name can exist outside of the *Genera* element table. Other examples include the location correction ("Adjusted") attributes in the *sites* element table and the use of the ITIS listings to check for taxa spelling errors. However, there are errors in the ITIS information as it remains a work-in-progress for invertebrates. Hand-checking was necessary to remove redundancies and correct errors. For example, checking observations from multiple sources with similar sites identified redundancies. Querying was done to remove logical errors such as having sample locations on land, or finding locations classed as intertidal in the offshore, or having a sample date later than the source publication date. Random checks were also made, but we did not use a protocol demanding a fixed percentage of random checking. Cross-checking the *sources* was particularly necessary with the earlier literature and had to be done by hand. Sometimes this was simple, for example, all observations dated 1878 could only have come from George Dawson's cruise. All data plotted for the figures of this report were double-checked. Finally, once museum collections are fully automated, we expect that naming errors and redundancies will be revealed.

MAPPING BIODIVERSITY

"*In order to produce such a map* (of biodiversity), *there must be some basic agreement about data standards, classification systems and spatiotemporal frameworks.*"

"*If we are going to develop decent biodiversity maps to inform policy then we need databases held together through more than just good metadata practice. In a biodiverse world we need to be thinking through ways of manipulating ontologically diverse data.*" (both Bowker 2000)

The proposed sea space of Gwaii Haanas was technically demarcated and agreed upon in the *South Moresby Agreement* (1988) and this intent was reaffirmed in the *Gwaii Haanas Agreement* (1993). Spatial approaches such as mapping species biodiversity and habitat data will be a key to the future of Gwaii Haanas. The core spatial task will be selecting areas (zones) within Gwaii Haanas for differing purposes to enable multiple sustainable uses while protecting biodiversity. Prioritization of zones, for reasons clearly defined through public consultation, will rely on sound science to underpin our GIS and its associated databases.

We envision a blend of zones for strict preservation ("no-take"), for transition ("buffer") areas and for various sustainable human uses that will comprise a Gwaii Haanas mosaic. Zones to foster *"ecologically sustainable use"* through to full protection are explicitly defined in both Parks Canada policy (Parks Canada 1994) and the proposed *Canada National Marine Conservation Areas Act*. For this, we will need GIS layers that respect, for example, traditional Haida uses and knowledge of invertebrates, long-term protection of especially biodiverse areas and representative ecosystems (e.g., kelp forest, seagrass meadow, deep-sea coral grove) and refugia for fished species.

Bowker's (2000) statements above support the importance of having, for example, a sound invertebrate classification system and recognized data standards. These include species names lodged with the ITIS or Haida names for *taxonomic units* agreed upon by the Elders in a sanctioned entity (SHIP) tasked with Haida language revival. The species biodiversity aspect, for example, appears sound for mapping because the data standard (species name) is recognized. What is altogether more challenging is linking the marine species with generalizations as to communities (species groups), habitat types and human use patterns in time and space. Agreement on such classifications will facilitate consultation concerning the process of zoning in Gwaii Haanas. There is a separate Haida place names database that could be overlain on, but not fully linkable with, our biodiversity data. This is because some place names apply to oral descriptions of marine area polygons, linear coastal segments, or land-with-sea places. Another related database suitable for overlaying but not linked into our database structure is of the 604 coastal archaeological sites in Gwaii Haanas' Archaeological Resource Description and Analysis (Fedje *et al.* 2001).

Conservation science is still developing ideas about and definitions of communities, habitats and ecosystems. In the near term, we must have some progress, through the precautionary approach, to support public consultation while science works to improve the technical bases for prudent decision-making. In British Columbia, for example, federal standards for subtidal mapping (Booth *et al.* 1996) and sampling are in hand (Robinson *et al.*1996) along with provincial standards for marine ecological classification (LUCO 2001). These methods represent an evolving technical expertise whose development has yet to yield universal agreement on coastal area application in British Columbia. In this report we will not review how the British Columbia methods were developed nor bench-test these methods with our data.

How should we map and apply our marine invertebrate species biodiversity knowledge? Where we have enough data for areas of Haida Gwaii, such as in Juan Perez Sound or Houston Stewart Channel, we may be able to link our species database with substrate and depth data to see whether patterns are yielded; something for the future given the early stage in Gwaii Haanas' marine knowledge development.

ABORIGINAL USES, NAMES AND STORIES OF MARINE INVERTEBRATES

"*... the rich stores of material of a former age to be found in the shell heap remains, are matters well worthy of the careful consideration of those who desire to make up a history ...*" (Swan 1874)

"*These* (northwest coast – southeast Alaska to Washington State) *were maritime peoples with their woodworking technology solidly grounded in the coastal forests, but their faces set to the sea winds. Over the centuries they evolved extremely efficient adaptations to their coastal marine environment that allowed population expansion and involved the exploitation of an extremely wide range of marine resources coupled with the intensive exploitation of a smaller number of marine resources that were available in large quantities at one time and could be stored for later consumption. Yet despite this intensive exploitation of marine fauna over centuries, as far as we know, at the beginning of the historic* (post-contact) *period, those resources were not depleted.*" (Hebda and Frederick 1990)

"*Fish and shellfish comprised the bulk of the aboriginal* (Haida) *diet ...*" (Blackman 1990)

"*...the northwest coast culture was unique: nowhere else on earth was fishing so crucial to the development of such sedentary, self-sustaining, and complex societies.*" "*...nowhere else on earth were human societies so fully integrated within marine ecosystems.*" (both Glavin 2000)

"*In order for Traditional Ecological Knowledge and Wisdom* (TEKW) *to be incorporated appropriately into current ecosystem-based management strategies, the complete context of TEKW, including its philosophical bases, must be recognized and respected.*" (Turner et al. 2000)

INVERTEBRATES AS FOOD

Various human cultures have occupied the Haida Gwaii region from at least 10,000 years before present [BP](Fladmark 1975, 1989; Ackerman 1996; Josenhans *et al*. 1997). This region is important to theories about coastal human migration from the northeastern Asian land link (Beringia) to Pacific North America between 14,000 to 10,000 years BP (Mandryk *et al*. 2001; Fedje and Mathewes *in preparation*). As well, Gwaii Haanas is rich in archaeological sites with 604 in the GIS database of the *Gwaii Haanas Archaeological Resource Description and Analysis* developed by Parks Canada (Fedje *et al*. 2001 a).

Coast-wide in the British Columbia area, by ≈6,000 years BP, there were well established human populations using a wide array of marine foods including invertebrates (Hebda and Frederick 1990). Further, by ≈3,000 years BP, the great abundance of coastal middens throughout British Columbia indicated to Hebda and Frederick that there was a marked population expansion with increasingly sedentary settlement patterns accompanied by "*intensive exploitation of intertidal shellfish resources*" and development of food preservation technology.

Until the early part of the 20th century, gathering nearshore marine invertebrates was likely important for human survival in Haida Gwaii. For example, proximity to invertebrate resources was a criterion in location of Haida winter village sites (Blackman 1990). Within the present Haida culture, knowledge and stories of marine invertebrates are an appreciable part of traditional knowledge.

Acheson (1998), in his settlement study of the southern Kunghit Island-area Haida, mentioned an early post-contact use of marine invertebrates from the Houston

Stewart Channel area where John Hoskins (aboard the *Columbia* in 1791) noted that *"clams, limputs, muscles and other shell fish"* were among Haida foods. More detailed early records on invertebrate usage were by Dawson (1880). Contemporary surveys of invertebrate usage for northern, Old Massett-area Haida are by Blackman (1976, 1979, 1990) and for southern, Skidegate-area Haida are by Ellis and Wilson (1981). Notes on contemporary Haida use of invertebrates are also provided in a fisheries overview by Jones and Lefeaux-Valentine (1991).

Blackman (1976, 1979, 1990) included invertebrate ("shellfish") observations in her overview of northern Haida resource use. Shellfish were usually consumed fresh, but cockle (*Clinocardium nuttallii*), purple-hinged rock scallop (*Crassadoma gigantea*), butter clam (*Saxidomus gigantea*) and northern abalone (*Haliotis kamtschatkana*) could be dried for winter use (Blackman 1979). At the end of winter, in the November to March period of resource scarcity, she suggested that shellfish "*...were probably a critical food source at lean winter periods.*" After salmonid (*Oncorhynchus* spp.) fishing in the fall, Haida storm-bound during northwest winter winds could readily gather intertidal shellfish and as they awaited better weather for spring Pacific halibut (*Hippoglossus stenolepis*) fishing. Access to shellfish was likely especially important if the fall salmonid yield was poor (Blackman 1990). Apparently, shellfish resources were in the public domain and not strictly lineage property such as salmonid streams or crabapple and berry patches (Blackman 1990). So, despite their strategic seasonal value, shellfish were allegedly not considered high status resources and Blackman (1976) recounted that they were *"...symbolically linked with commoners"* and she later mentioned that shellfish were *"...not served at feasts or potlatches"* (Blackman 1979). Both Haida genders gathered invertebrates (Blackman 1990).

Given the possible low status of shellfish gathering, it is possible, but not confirmed, that the Haida used their slaves to gather invertebrates, as they did use slaves to get finfish (Donald 1997, p. 318).

After the smallpox epidemic of the 1860s, the far southern **G̲anxiid** [Kunghit Island area] Haida were reduced to occupying the main Gwaii Haanas regional village site of **Nan Sdins** on **SG̲aang Gwaii** (Anthony Island). This village was no longer occupied year-round after the late 1880s and the **G̲anxiid** people settled mostly in Skidegate. It would seem likely, therefore, that the **G̲anxiid** knowledge of invertebrates became blended with Skidegate knowledge reported in Ellis and Wilson (1981). The only other dedicated contemporary survey of marine invertebrate use by First Nations of British Columbia is that of Ellis and Swan (1981) for the Manhousat people, Flores Island area, west coast of Vancouver Island.

The invertebrate species used by the Haida listed from Dawson (1880) and Ellis and Swan (1981) are provided in Table 5. An interesting speculation of Ellis and Wilson (1981) was that California mussel (*Mytilus californianus*) and red sea urchin (*Strongylocentrotus franciscanus*) populations may have been in a state of semi-cultivation of enhanced growth by the repeated thinning. Listed in Appendix C are the northern and southern Haida words for marine invertebrates according to Blackman (1979) and Ellis and Wilson (1981) respectively, plus those southern Haida words recently revised courtesy of the Skidegate Haida Language Authority, Skidegate Haida Immersion Program (SHIP 2001). Haida dialects from the northern and southern areas of Haida Gwaii differ appreciably (Enrico 1989). All southern (Skidegate) Haida words are under review by the Language Authority to clarify

Table 5. Marine invertebrates eaten by the Haida according to Ellis and Wilson (1981).

Mollusks

Northern abalone (*Haliotis kamtschatkana*)
California mussel[1] (*Mytilus californianus*)
Blue mussel (*Mytilus trossulus*)
Purple-hinged rock scallop (*Crassadoma gigantea*)
Weathervane scallop (*Patinopecten caurinus*)
Nuttall's cockle[1] (*Clinocardium nuttallii*)
Butter clam[1] (*Saxidomus gigantea*)
Native littleneck clam (*Protothaca staminea*)
Razor clam (*Siliqua patula*)
Horse clams (*Tresus capax / Tresus nuttallii*)
Geoduck clam (*Panope abrupta*)
Piddock [boring clam] (*Zirphaea pilsbryi*)
Octopus (*Enteroctopus dofleini*)
Gumboot chiton[1] (*Cryptochiton stelleri*)
Black katy chiton[1] (*Katharina tunicata*)

Crustaceans

Barnacles (*Balanus* and *Semibalanus* spp.)
Goose barnacle (*Pollicipes polymerus*)
Pelagic goose barnacle (*Lepas anatifera*)
Dungeness crab (*Cancer magister*)
Red rock crab (*Cancer productus*)
Red king crab (*Paralithodes camtschatica*)
Box crab (*Lopholithodes mandtii*)
Shrimps (*Pandalus* spp.)

Echinoderms

Sea cucumber[1] (*Parastichopus californicus*)
Red sea urchin (*Strongylocentrotus franciscanus*)
Green sea urchin[1] (*Strongylocentrotus droebachiensis*)
Purple sea urchin[1] (*Strongylocentrotus purpuratus*)

Tunicates

Hairy sea squirt (*Halocynthia hilgendorfi*)

[1] mentioned by Dawson (1880) as Haida food

spelling and pronunciation (B. Wilson, Gwaii Haanas, *personal communication*).

The preparation (handling and cooking) of some invertebrates could be specialized. For example, the meat-rich siphon tips of clams (areas where paralytic shellfish poison has been scientifically demonstrated to concentrate) were always discarded by southern Haida during food preparation (Ellis and Wilson 1981). Blackman (1979), on the other hand, stated that only the siphons of horse clam (*Tresus* spp.) were eaten by the northern Haida. Ellis and Wilson (1981) mention that sea cucumber and chiton were always prepared according to tradition. However, traditional knowledge of specific treatments according to species and the full spectrum of species that can be consumed is being lost or is being replaced with new knowledge according to new technologies and changing cultural tastes (Ellis and Wilson 1981).

As with other coastal British Columbia Aboriginal peoples, the Skidegate Haida were aware of when bivalves became toxic (with paralytic shellfish poison). Haida traditional knowledge correctly identified these toxic events as seasonal, plankton-associated phenomena (Ellis and Wilson 1981). Dawson (1880) reported an April to October abstention observed by the Haida from eating bivalves. This abstinence period, however, was not universal as John Boit recorded Haida eating roasted mussels in the summer of 1791 in the Houston Stewart Channel area (F. Howay 1941 in Acheson 1998). Whether this had to do with local conditions or knowledge of when an area was contaminated in unknown (S. Acheson, British Columbia Archaeology Branch, *personal communication*).

From Skidegate Haida stories, Ellis and Wilson (1981) recounted the story:

"Why the people of Skidegate Inlet can eat seafood all year"

*Every spring, **k'ilydáng-ga**, the poison jellyfish travels about in his big canoe distributing his poison. Wherever he went, people could no longer eat seafood, because he poisoned it. He visited every part of Haida Gwaii. Finally, he* *came to Skidegate Inlet, but his canoe grounded on Sandspit bar and he could not pass through. So, he turned back and never came to Skidegate Inlet again. That is why the people in the Inlet can eat seafood all year.*

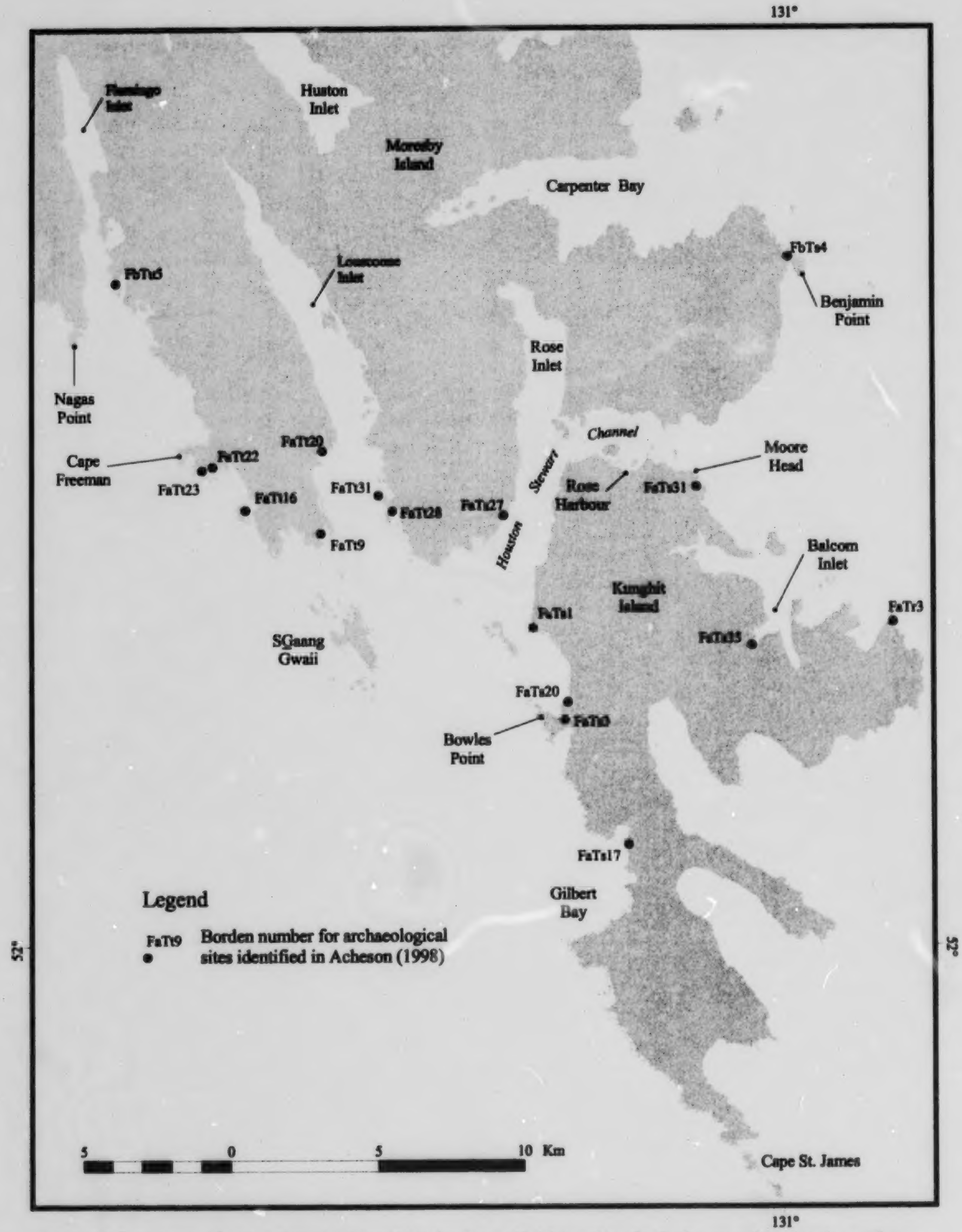
Two interesting traditional Haida views of invertebrates involve "lucky" seafood and lines of descendance (Ellis and Wilson 1981). Living marine invertebrates found (by very good luck) on land were reputed to have supernatural qualities. For example, live northern abalone or red sea urchin encountered in the forest should be eaten by the finder immediately for the foods' good luck to be manifested. Red sea urchin were said to have descended from salmonberries, abalone from the forest toad and the butter clam from the weasel. The reasons for these lineages are unclear.

Current shorelines represent only a part of the history of coastal occupation of Haida Gwaii due to sea-level fluctuations (Fedje and Christensen 1999). Midden sites, with abundant invertebrate shells, have long been known as common features along the Haida Gwaii coast. For example, shell middens have been recorded at 369 locations in the Gwaii Haanas area alone (I. Sumpter, Parks Canada, *personal communication*). Most shoreline middens document approximately the last two to three millennia when sea levels approximated those seen today in Haida Gwaii.

Dawson (1880, p. 95B) provided the first account of four mollusc species from middens (butter clam, littleneck clam [*Protothaca staminea*], cockle, leafy hornmouth snail [*Ceratostoma foliatum*]). The largest archaeological survey with detailed invertebrate information is by Acheson (1998) from digs at 18 (17 randomly selected) of 114 G̲anxiid archaeological sites he mapped in southern Gwaii Haanas (Figure 4). These represent part of the last 1600 years of G̲anxiid pre-European-contact occupation. Some 59 species of marine invertebrate were identified from midden and dwelling (house pit) soil strata (Keen 1990). The nine most common invertebrate species or groups are listed in Table 6. The extent to which these deposits represent historical Haida diets will likely always be speculative. For example, California

Table 6. The percentage weight of total invertebrate shell remains excavated from 18 Kunghit Island-area Haida sites in southern Gwaii Haanas (extrapolated from data in Acheson 1998).

Species or Group	**% weight of shell remains**	
	Mean	**Range**
California mussel (*Mytilus californianus*)	89.6	26.0 – 99.3
Barnacles (*Balanus* and *Semibalanus* spp.)	6.7	0.08 – 62.2
Clams (various species)	1.6	0.0 – 18.6
Chitons (various species)	1.4	0.14 – 6.1
Sea urchins (*Strongylocentrotus* spp.)	0.3	0.0 – 1.3
Limpets (various species)	0.2	0.0 – 1.7
Sea snails (various species)	0.1	0.0 – 0.5
Rock scallop (*Crassadoma gigantea*)	0.1	0.0 – 3.5
Northern abalone (*Haliotis kamtschatkana*)	<0.01	0 .0– 0.09



131°
Flamingo Inlet
Huston Inlet
Moresby Island
Carpenter Bay
FbTs4
Benjamin Point
FbTt5
Louscoone Inlet
Rose Inlet
Nagas Point
Channel
Moore Head
FaTt20
Cape Freeman
FaTt22
FaTt23
FaTt16
FaTt31
FaTt28
FaTt27
Stewart
Rose Harbour
FaTs31
FaTt9
Houston
Balcom Inlet
Kunghit Island
FaTs1
FaTr3
FaTs35
SGaang Gwaii
FaTs20
FaTs3
Bowles Point
FaTs17
Gilbert Bay
Legend
FaTt9
Borden number for archaeological sites identified in Acheson (1998)
52°
52°
5
0
5
10 Km
Cape St. James
131°

Figure 4. Locations of the 18 G̲anxiid (Kunghit Island-area Haida) archaeological excavation sites in southern Gwaii Haanas (based on the maps published by Acheson, 1998). Acheson (1998) used the Borden system for archaeological site identification based on geographical coordinates and the order of discovery. Parks Canada does not use the Borden system.

mussels often harbour attached barnacles which could subsequently fall off when cooked or over time in a midden. Rocky shore species dominate in Table 6. Among these, California mussel shell comprised ≈90 % of all site deposits. These large bivalves are readily available along the mid intertidal of southern Gwaii Haanas' largely rocky coast. The low representation of clam shell may reflect the relatively small amount of sheltered sediment beaches (prime clam habitat) in this predominantly rocky region. Keen (1990) mentioned that one site, at the head of Balcom Inlet [FaTs 35], with 48 % California mussel, 29 % barnacles (*Semibalanus* spp.) and 19 % clams represented foods reflecting a more protected (more sedimentary shore) location. However, California mussels are normally limited to wave-exposed shores. Such exposed shores occur only a few km from the head of Balcom Inlet. Elsewhere along the British Columbia coast, littleneck clam, butter clam and blue mussel (*Mytilus trossulus*) dominate coastal midden invertebrate remains with little mention of California mussel (Hebda and Frederick 1990). This may reflect a bias from the south in that middens in relatively protected waters such as along the Strait of Georgia coasts dominate among the sampled sites compared to Acheson's exposed coast work.

Northern abalone and sea urchins comprised very small shellfish components. Both species are confined to the very low intertidal to shallow subtidal. They would, therefore, be less available for easy gathering than the mid intertidal California mussels. As well, it is unknown whether this represents abalone shell recycling for other uses or limited availability of abalone due to sea otter predation on abalone in pre-contact coastal ecosystems. Abalone shell survivorship itself is not likely an issue as other mollusk shells persisted in middens. The porous sea urchin tests (shells) and spines would be less likely to survive under residual low pH (acidic) conditions than mollusk shells. However, in the more extensive middens, the mass of shell material would likely increase the pH in normally acidic soil and groundwater, thus promoting shell preservation.

From another Kunghit Haida site, north of Acheson's (1998) area, at **G̲andll K'iin** [Hotspring Island], a midden was sampled by Parks Canada in 1993 and 1999 (Sumpter and Mason 1994; Sumpter 1999). The 1993 work revealed 13 species including northern abalone in the midden dating ≈1,700 years BP. The dominance of infaunal clam species at all midden levels indicated harvesting in *"a protected environment such as quiet bays with sandy and gravelly mud substratums"*(Sumpter and Mason 1994). In 1999, samples yielded ≈9.3% California mussel shell, ≈58% sediment-dwelling clam shell (mostly venerids such as littleneck and butter clams) and ≈16% barnacle shell among the 42 taxa recorded. This likely reflects relatively greater access to sandy beaches for invertebrate harvest compared to the more rocky habitats providing different invertebrates further to the south (Acheson 1998).

The oldest archaeological site excavated to date from Haida Gwaii is the stone tool scatter and midden site (**Kilgii Gwaay**), dating ≈9,400 years BP, in the intertidal near the warden operations station on Ellen Island in Gwaii Haanas (Fedje *et al.* 2001 b). Preliminary assessment of the invertebrate remains from this exciting and unique site reveals a similar marked dominance of California mussel as reported by Acheson (1995, 1998) from other, much more recent (≈1,700 years BP), southern Haida Gwaii midden sites. That may mean that for many millennia in the rocky, southern Haida Gwaii region California mussel dominated the invertebrate component of indigenous peoples' diets.

There are few detailed published reports of invertebrate species in shell middens from elsewhere in Haida Gwaii. In the Prince of Wales archipelago, Alaska, just north of Haida Gwaii, an 8,200 year old midden was excavated (Ackerman 1996). There is a ≈6,000 BP Moresby Tradition era midden site at Cohoe Creek that drains into the sheltered shores of Masset Inlet near Port Clements (Ham 1990; Ackerman 1996). The site's vertebrate remains are dominated by jack mackerel (*Trachurus symmetricus*) and the extinct Dawson's caribou (*Rangifer tarandus dawsoni*) (Wigen and Christensen 2001). Among the invertebrate remains, shells of burrowing clams dominated with no California mussel shell, but some blue mussel shell (Ham 1990; T. Christensen, Department of Archaeology, Simon Fraser University, *personal communication*). Through Ham's (1990) analyses of clam shell growth bands, he demonstrated winter-time gathering. At Blue Jackets Creek, on the eastern side of Masset Sound ≈2.4 km south of Masset town, Severs (1974 a) reported on a midden dig of ≈2,200 to 3,600 years BP. Shellfish remains in strata were dominated by sedimentary and sheltered shore bivalves such as butter clam and blue mussel. California mussel shell was rare in the deposits. In a preliminary analysis of a ≈4,000 years BP midden (at ***Hiellen*** village site) on the exposed sandy North Beach, near Tow Hill (≈27 km northeast of the Masset area), mollusk material was dominated by horse clam and razor clam (*Siliqua patula*) with no California mussel (B. Wigen, Department of Anthropology, University of Victoria, *personal communication*). From another Tow Hill midden site, Severs (1974 b) reported a dominance of sedimentary shore butter, littleneck and razor clams, but no rocky shore California mussel. The presence of the specialized high surf sand beach razor clam led Severs (1974 b) to link midden contents to local ecosystem type and propose "*...some continuity for the type of shoreline ...*".

In summary, invertebrate species harvested by indigenous Haida Gwaii peoples in the past likely reflect pragmatic opportunism according to the food species dominating in nearby habitats. California mussels, and to a lesser extent barnacles, dominated in middens on or near wave-exposed rocky shores, while burrowing clams dominated in middens on or near wave-protected sediment shores. Keen (1990) concluded that the Kunghit Island-area Haida pattern of using locally abundant species was similar to those found at other Aboriginal midden sites along the British Columbia coast.

HAIDA, ABALONE SHELL AND SEA OTTER

Abalone is special because the shell's beauty attracted Aboriginal peoples. The Haida used abalone shell as inlay in monumental art and for personal adornment. Illustrated twice in MacDonald (1994) (plate 189, p. 143 / plate 277, p. 213) is an interior pole depicting a standing beaver biting an abalone-inlaid stick. This pole came from the "Monster House" of chief Wiah built ≈1840 in Old Massett village. It is unknown when the pole was installed, but it was collected in 1902 by C.F. Newcombe and is now in the Canadian Museum of Civilization (CMC), Hull. The species of abalone used in the inlay is unknown (L. Tepper, CMC, *personal communication*). Abalone shell was also used to decorate personal items. In the 1885-1890 Fleming brothers photograph, two high-ranking Haida (Tom Price and John Robson) are wearing frontlets (head ornaments) bordered with abalone inlay (Jonaitis 1988, Fig. 3). However, this photograph may be misleading as it was taken in a Victoria studio and the frontlets could be of unspecified north coast regional, not Haida, origin (B. Wilson, Gwaii Haanas, *personal communication*).

In 1787 Capt. George Dixon purchased a labret (a high-status woman's pierced-lip ornament) with a copper rim and inlaid with abalone shell near Hippa Island off the west coast of Graham Island. It would be intriguing to know whether such decorative abalone is from the local northern abalone or from larger, thicker-shelled California-area species such as the red abalone (*Haliotis rufescens*) or the green abalone (*H. fulgens*). Don Jacinto Caamaño, after visiting **Kiusta** village (Graham Island) in 1792, reported that the Haida wanted to trade their sea otter furs for green-coloured abalone shell similar to that which he had seen in the California area: "*... they desired to have as green a colour as those that some wore in great numbers hanging at their ears. We were surprised to see that several had those of a sort that is found only at Monterey... I inquired who had given them the Monterey shells but either they did not catch my meaning, or I misunderstood their reply* (Gessler and Gessler *no date*). The Gesslers reported that three green abalone shells from a midden in **Kiusta** were apparently identified by the British Columbia Provincial Museum as *H. fulgens*, a species known from south of Point Conception, CA (Lindberg 1992). These shells are at the Haida Gwaii Museum (N. Macfarlane, Haida Gwaii Museum, *personal communication*). This may have been abalone shell acquired by trade between Aboriginal peoples along the Pacific coast before contact with Europeans. The Haida elder Robert Cogo of Ketchikan, AK is cited as follows: "*In 1790, the fur traders came from California with big abalone shell. The Haida took it in trade for sea otter furs. They were highly prized and the artists took and made buttons and ornaments. Later on they brought wool blankets and pearl shell buttons*" (www.dorothygrant.com/).

Abalone shell was traded extensively among Aboriginal peoples in southwestern (Howorth 1978) and northwestern (Fitzhugh and Crowell 1988) North America. Stewart (1973) speculated that early American traders imported California-area abalone shell as a commodity along the northwest coast, but she cited no historical sources. Abalone shell jewelry and inlay decoration of personal items, dating back at least to the 1820s, is known from Nuxalk (Bella Coola area), Heiltsuk (Bella Bella area), Kwakiutl (northeast Vancouver Island), Tsimshian (Prince Rupert region) and Tlingit (southeast Alaska) cultures (Jonaitis 1988, Plates 7, 11, 12, 13; Jonaitis 1991, Figs. 3.15a, 3.15b; Brown 1998, Figs. 3.17, 4.36, 4.37 4.44, 4.45, 4.46, 4.47, 5.30, 5.31).

The Skidegate Haida received abalone (perhaps red and/or green abalone) shell pieces in trade and had a separate name (**gwúlx̱a**) compared to northern abalone (**gálgalh iiyáan**), although the whole shells of the two species were apparently named the same (**gálgalh iiyáan ḵ'áal**) (Ellis and Wilson 1981). The fact that SHIP recorded six words for abalone reflects perhaps that different species were recognizable and/or that likely more than the acknowledged four Haida dialects existed (B. Wilson, Gwaii Haanas, *personal communication*).

Competition for northern abalone between the Haida and sea otters was possible. The sea otter population of Haida Gwaii was likely intact, although hunted and perhaps locally depleted around the larger habitation sites, prior to the vigorous sea otter fur trade between Haida and Europeans and Americans from the 1790s to ≈1840s. Sea otters are voracious predators of northern abalone (Watson and Smith 1996). Further, low population levels of abalone species are known to occur in areas occupied by sea otters in British Columbia (Breen *et al.* 1982; Watson 2000) and California (Lowry and Pearse 1973). It is possible, therefore, that northern abalone were most available to Haida along rocky coasts where sea otters were hunted in the pre-contact era.

Moreover, particularly after ≈1840, northern abalone may have become more available for gathering throughout Haida Gwaii because of reduced sea otter populations.

MARINE INVERTEBRATE SPECIES BIODIVERSITY AND BIOGEOGRAPHY OF THE HAIDA GWAII REGION

"An understanding of marine biodiversity is indispensable for advances in all fields of biology, including ecology, fisheries and aquaculture, conservation and pollution." (Grassle *et al.* 1991)

"Rather than striving to maintain some specific level of diversity, we should endeavor to understand the basic ecological processes that control populations, communities and ecosystems so we can best predict what kinds of stresses will cause the most serious alterations to the system and avoid them." (Suchanek 1994)

"This (marine biodiversity) *agenda requires significant advances in taxonomic expertise for identifying marine organisms and documenting their distributions, in knowledge of local and regional natural patterns of biodiversity, and in understanding of the processes that create and maintain these patterns in space and time."* (NRC 1995)

"A profound problem for (marine) *conservation is that there is very little information about the relationship between species diversity and ecological function."* (Ray 1996)

"Any human activity that results in substantial resource extraction or modification will always entail significant, often unknown, and almost always unappreciated consequences for one or more biodiversity components (genetic, population/species, community ecosystem), *primarily by redirecting matter and energy flows."* (Redford and Richter 1999)

"One reason we've done a woeful job of conserving marine biodiversity is that we lack an understanding of what and where it is." (Elliott Norse in Malakoff 2000)

SPECIES BODIVERSITY AND INVENTORY IN MARINE CONSERVATION

This section provides context on the scientific roles of invertebrate species inventory for biodiversity assessment in marine area conservation. Why should we focus on this now, in the early stages of Gwaii Haanas' marine area establishment? We discuss these issues at a time of rapid change in world-wide marine area conservation science.

Biodiversity maintenance and ecosystem protection are central organizing principles of conservation. Fundamental to these principles is creating taxonomically and systematically reliable species inventories. Inventories aid Parks Canada's proposed marine mandate by creating baselines upon which the overall knowledge base can be built. Further, our inventory is spatio-temporal in a GIS, which enables sophisticated enquiry and efficient updating as a core long-term science asset for Gwaii Haanas.

Inventories reveal data gaps, that, when prioritised, could focus future knowledge gathering. New (1995) points out, however, that managers find it difficult to accept that, unlike birds for example, there can be uncertainty by orders of magnitude for invertebrate species diversity in conservation areas. Haida Gwaii is no exception – this inventory scratches the surface of an immense marine invertebrate assemblage we know little about.

It is remarkable that invertebrate inventories are so often overlooked in conservation management. Stohlgren *et al.* (1994) stressed that *"poor or non-existent"* status of invertebrate inventories in national parks was not uncommon for the groups outside the charismatic megafauna such as birds and mammals. Looking into the future, we are confronted with the daunting problem of poor capacity to understand marine invertebrate species diversity.

What role does species inventory have in achieving progress in marine area conservation science and management? It is important to prioritize the potential contribution of species baselines among the many initiatives demanding attention (and funding) in marine conservation. It is also important to understand the limitations of species-level approaches to understanding overall marine biodiversity. Species-level biodiversity is but a part of the many attributes of biodiversity as a whole. A discussion of the limitations and contributions of species biodiversity to marine conservation is, therefore, warranted.

Biodiversity is a complex, nested system of entities and processes. One hierarchical approach to examining biodiversity, applicable to land or sea, frames the three main attributes of ecosystems (composition, structure, function), each of which possess four levels of organisation (regional [seascape], community-ecosystem, population-species, genetic) (Noss 1990). Species lists relate to composition (the identification and variety of elements), and contribute less to illuminating ecosystem structure and function.

Another, specifically aquatic, scheme identifies three hierarchies: *taxonomic* (species to kingdom), *genetic* (allele to genome) and *ecological* (population to biosphere) (Angermeier and Schlosser 1995). Within the *ecological*, biotic and physical factors may be used to classify assemblages (above the population level) at each of four hierarchical levels (geographic region, local seascape, primary community [higher taxa, e.g. class, family] and secondary community [lower taxa, e.g. species]).

Zacharias and Roff (2000) further adapted Noss' (1990) biodiversity framework to the sea, focusing on marine ecological function at the community and ecosystem levels of organization. They proposed that marine conservation science should lead with the more observable physical and chemical parameters, as follows: "*The distinction between the biotic (and community) and abiotic (ecosystem) is required because the biological components of biodiversity such as competition or predation are often more difficult to observe than the abiotic components such as upwelling, substratum, or temperature. As a result, efforts to conserve marine biodiversity are often dependent on the observable abiotic* (ecosystem) *components, which can be used as surrogates for the identification and monitoring of biotic* (genetic, population, community) *components.*" This is controversial for some biologists who say that this is not enough (Salomon *et al.* 2001) - that knowledge of biotic interactions (connections of habitat diversity to species' life cycles) are not adequately considered. Further, there is doubt whether abiotic factors can effectively be used as surrogates except at the crudest levels. The ecosystem level is not devoid of biotic components, but rather those components may be functional analogues of species that can vary taxonomically from community to community. In other words, the niches within an ecosystem may be approximated by different species in different communities. From a conservation standpoint, if we protect a group of species comprising the biotic components of an ecosystem, we protect the ecosystem. But, if we protect ecosystems based on abiotic factors, we could lose species which require biotic factors and/or some particular blend of abiotic factors. The fundamental problem remains concerning the degree to which biological and physical processes structure various types of marine communities. Such understanding should be a long-term goal for Gwaii Haanas, but we are currently far from such a sophisticated level of knowledge.

Biodiversity science has been dominated by research into composition at the species-population level (Angermeier and Schlosser 1995). Lagging behind are the more difficult issues of structure (e.g., physical organisation, habitat complexity) and function (e.g., ecological and evolutionary processes such as gene flow and nutrient cycling). Zacharias and Roff (2000) have stated: " *... structure is the result of the operation of process, and therefore ... observing structure can be used as a surrogate for inferring process, which often is unobservable."* Using structure as a surrogate for inferring process is questionable, as, for example, this assumes that there is only one process that results in a given structure. As well, structure is relatively static, and it is the speed of process (e.g., nutrient turnover) which can be central to ecosystem function.

Despite the unfolding debate over biotic and abiotic approaches, biodiversity maintenance remains a leading science objective in implementing marine conservation through protected area designations (Jones 1994; Ballantine 1995; Ticco 1995; Sobel 1996; NRC 2001). The lack of an approach embracing the true hierarchical complexity of biodiversity has tended to relegate efforts to "*.... haphazard preservation of fragments of disintegrating systems*" (Angermeier and Schlosser 1995).

While society debates marine conservation policy and objectives, basic inventory work can progress to help prepare a solid foundation for when there is greater unanimity on how best to protect marine areas in the long term. In other words, unlike the social and economic complexities of establishing a marine conservation area with its boundary delineation and zoning, technical inventory is politically inert and can proceed with little disruption. Moreover, there is a pressing need to be seen working now on starting points of marine biodiversity, despite our rudimentary understanding of its true complexity. For example, although we are unable to account for Gwaii Haanas marine biodiversity at broader levels, we should move forward with what is achievable now, such as thorough species inventories based on information already in hand.

We must eventually delineate assemblage or habitat types according to patterns of species' occurrences. However, the dynamism imparted on Gwaii Haanas ecosystems by physical oceanographic processes, sea bottom substrate and bathymetry add to the challenge of applying marine biodiversity knowledge. Examples are that nearshore currents are unknown, yet critical to understanding connectivity between nearshore areas through larval transport and that the effects of seasonal upwelling and intrusion of cold (nutrient-rich) and warm (nutrient-poor) waters are poorly understood. Therefore, complimentary oceanographic (physio-chemical) knowledge will have to be acquired and evaluated with biodiversity knowledge of Gwaii Haanas before science can sufficiently support core marine management initiatives such as zoning to enable coexisting multiple sustainable uses.

We summarize the steps towards understanding the functional biodiversity of Gwaii Haanas' marine ecosystems over the long term, in order, as follows:

- develop baselines of species listing and mapping on GIS;
- define distinctive assemblages of named species associated with abiotic factors; and
- describe dominant species in assemblages based upon numbers, biomass, turnover rate, species interactions, etc. The dominant species could be candidates for monitoring as discussed later.

In the long term, protecting distinctive assemblages (e.g., communities) provides the ecological and evolutionary context for populations (Angermeier and Schlosser 1995). These authors state that the assemblage approach has been lacking in conservation policy and not knowing even how many types of assemblages exist impedes progress.

On a final note, there is inherent conflict in maintaining biodiversity while enabling sustainable use (Redford and Richter 1999). This relates here to the exclusion of human effects of invertebrate fishing, or intertidal trampling by tourists, through zoning as discussed later in the management section. Further, Steele (1998) challenges even applying the idea of biodiversity to the sea, given extraction by fisheries and inherently unstable baselines typified by ocean regime shifts (reviewed for the North Pacific by Glavin 2000). Although Steele has a point in the highly dynamic pelagic realm, the biodiversity idea may have more relevance in the benthic realm of long-term spatially persistent invertebrate populations (e.g., geoduck clam beds) and the structures invertebrates can create (e.g., coral reefs). Nonetheless, we underscore that science is in the early stages of providing sound understanding of marine ecology and this is a time of great change in marine area conservation science.

REGIONAL MARINE INVERTEBRATE ZOOLOGY HISTORY

"The marine conditions associated with abundance of the species were investigated, as yet largely with the idea of exploitation in mind. Scarcely anyone dreamed of the necessity of conservation." (Fraser 1942 a – on north Pacific zoological research in the late 19th – early 20th centuries)

This section summarizes the history of Haida Gwaii regional marine invertebrate investigations from European contact to the present. The first record of Europeans sighting land between Monterey, CA and Cape St. Elias, AK was near Langara Point (Langara Island) on July 17, 1774 by Juan Perez commanding the Spanish corvette *Santiago*. The Haida who came out to trade already had iron, either from shipwrecks (Asian?), earlier unrecorded contact or through trade among aboriginal peoples. The Spaniards did not land and recorded no observations on marine invertebrates.

In 1787 Captain George Dixon, a former member of Captain Cook's third global voyage, sailed south to trade for sea otter pelts with Haida in Cloak Bay, Langara Island. Dixon continued south and realized that this was an archipelago which he named the Queen Charlottes Islands after his vessel *Queen Charlotte* (Dalzell 1973). A year earlier, three vessels (*Sea Otter, Captain Cook* and *Experiment*) had traded for sea otter pelts in the southern Moresby Island area. By 1789 ships' crews were going ashore, although we have found no records of observations or collections of marine invertebrates. José Maldonado, a naturalist aboard the Spanish frigate *Aránzazu* commanded by Jacinto Caamaño in 1792 collected marine invertebrates during a voyage to Bucareli Bay [≈55.25° N] in present southeast Alaska (Wagner and Newcombe 1938). Much scientific material (and kudos) from Spain's excursions in the northeast Pacific has, however, been lost or overlooked (Engstrand 2000).

By 1800 many ships were coming to the region for the sea otter trade, not scientific exploration (Gough 1989). Sea otter populations were quickly decimated coast-wide and by 1834 they were uncommon in Haida Gwaii (Dalzell 1968). By the middle of the 19th century, visitors began to take an interest in other natural resources of Haida Gwaii. The Hudson Bay Company learned about local gold-bearing rocks and the

California gold rush of 1848 resulted in Americans exploring along the coast including Haida Gwaii. The British responded by sending naval vessels to the Haida Gwaii to establish a presence. Their activities included hydrographic surveys to chart the coast (Parizeau 1929; Gough 1971, 1989). While such surveys often include the collection of marine animals, we have not found evidence of invertebrate collections from this period.

The geologist Francis Poole surveyed for copper in the Burnaby Island area in the early 1860s. Poole (1872) listed 17, mostly misidentified, species of shellfish collected from Burnaby Island. He collected many more species, but these were destroyed in a bush fire. In 1865 the first crown grant (Haida interests were ignored) was made to a coal mining company on land west of Queen Charlotte City (Dalzell, 1968). The Geological Survey of Canada had a policy to aid exploration for coal and other mineral deposits (Sutherland Brown 1968). In 1872 the Survey sent James Richardson to make a preliminary survey of coal deposits in western Skidegate Inlet. Dall (1897) thanked Richardson for providing mollusks, but he is not named in reference to any species recorded from Haida Gwaii.

George Dawson traveled by the small (≈20 ton) schooner *Wanderer* along the whole east and north coasts of Haida Gwaii in 1878 for the Geological Survey of Canada (Dawson 1880). In addition to establishing a geological overview for the Islands, George, and his brother Rankin, also recorded flora, fauna and ethnographic information. They collected intertidal marine invertebrates by hand and subtidal species by dredging. Specimens were identified by Whiteaves (1880, 1894), Smith (1880), Lambe (1893, 1894), Verrill (in Whiteaves 1880), Dall (in Whiteaves 1880), Hincks (1884) and Fraser (1911). In his journal Dawson provides personal observations on marine invertebrates (Cole and Lockner 1989). For example, when first arriving to Haida Gwaii and entering Houston Stewart Channel, Dawson notes *"the rocks everywhere about this passage are crusted with Acorn shells* (likely *Balanus* sp.), *and the large mussels* (likely *Mytilus californianus*) *between tidemarks, with occasional patches of Lepas* (likely the goose barnacle *Pollicipes polymerus*) *etc. Below high water mark in some places the large urchins* (likely *Strongylocentrotus franciscanus*) *are very thickly strewn over the bottom. Sea anemones* (likely *Anthopleura xanthogramica* but may include *Urticina* spp.), *starfish etc. etc. are everywhere abundant."* Dawson's reference to the high populations of red sea urchins, which still occur today, likely reflect the rarity of its key predator the sea otter. Dawson also used a small dredge in Houston Stewart Channel and noted the many beautiful bryozoans (later identified by Hincks 1884), some corals (*Paracyathus caltha* and *Allopora venusta* in Whiteaves 1880) and a brachiopod (*Terebratalia transversa*). At the north end of Haida Gwaii, Dawson commented on dredging in 111 fathoms (≈205 m) where he brought up many brittle stars (*Ophiura leutkeni*). The locations of the Dawsons' collecting stations were compiled in the review of dredging in British Columbia (1878 to 1966) by Bernard *et al.* (1967) and are in our database.

The history of early marine science explorations in the northeast Pacific is summarized in Fraser's (1942 a) presidential address to the Royal Society of Canada. The Smithsonian Institution, Washington, D.C. commissioned biological surveys in the Haida Gwaii area in 1883 (Swan 1884). Also in 1883, the U.S. Fish Commission launched the steamer *Albatross* to undertake deep-water surveys mostly along U.S. coasts. The *Albatross* began work in the northeast Pacific in 1888, doing pioneering work particularly in the deep-sea. A few of its stations were nearby Haida Gwaii. For example, station 3342 in Sept.

1890 was a beam trawl at 1,588 fathoms (2,931 m) depth west of Moresby Island (52° 39′ 30″ N′; 132° 38′ 00″ W). It was noted (Tanner 1893) that *"among the invertebrates were an octopus, barnacles, shrimps, sea-anemones, amphipods, starfishes, two species of corals, hydroids, and several beautiful stalked crinoids, which were secured in the best of order"*. The *Albatross* operated periodically in the region until 1915 and the invertebrate biota from her surveys generated many publications.

In 1884 N. Chittenden explored Haida Gwaii for the British Columbia government (Chittenden 1884). He remarked on *"… enormous quantities of mussels of great size, some measuring eight and ten inches in length, covered the shores in many places…"* and *"I have seen a good many crabs in other waters, but never one-hundredth part as many as suddenly appeared on the shore of Sterling Bay* (north shore of Skidegate Inlet ≈4 km from Skidegate) *in the latter days of July. The lowest estimate by any one who saw them, was tens of thousands. The bottom in places was so thickly covered that nothing but crabs were visible, and Messrs. McGregor and Smith reported having found them two or three feet in depth. They were not the coarse, overgrown, worthless sea crab, but a good eating variety, which for some unknown cause had come there in such great numbers, for the purpose casting their shells* (moulting). *They remained about ten days, when they left in a body, leaving a winrows of their old shells on the beach. Mr. Alexander McKenzie reports a similar visitation at Masset, the first known during his six years' residence on the island."*

By 1886 British Columbia had established a provincial museum and in 1890 the Natural History Society of British Columbia was founded – both in Victoria. These fostered increased naturalists' explorations. For example, C.F. Newcombe visited Haida Gwaii eight times and included collecting of marine invertebrates along with his ethnological and other natural history observations (Newcombe 1891). Several molluscs collected by Newcombe from Cumshewa Inlet and Skidegate Channel were described as new species by Dall (1897).

The late 19th and early 20th century saw the first marine biological facilities established in the northeast Pacific: Hopkins Marine Station, Pacific Grove, CA (1892), Minnesota Seaside Station, Port Renfrew, B.C. (1901 – closed ≈1906), Puget Sound Biological Station, San Juan Island, WA (1904 – replaced by Friday Harbor Laboratories on San Juan Island in 1909), Scripps Memorial Marine Laboratory, La Jolla, CA (1905) and Pacific Biological Station, Nanaimo, B.C. (1908). After establishing the Pacific Biologicval Station, the Biological Board of Canada established a Fisheries Experimental Station in Prince Rupert in 1926. It had year-round staff focused mainly on economic uses of marine resources such as fish oil research. Little pure invertebrate zoology was done there and no fieldwork was done in Haida Gwaii from the laboratory, which was closed in 1942 and its staff was sent to a Vancouver laboratory.

George Taylor, the first curator of the Pacific Biological Station did much collecting by dredging, including some areas in Haida Gwaii (Butler 1980). Visiting scientists took advantage of Pacific Biological Station as a base for summer operations and some visited Haida Gwaii to collect (C. Fraser - hydroids; F. Potts-polychaetes and parasitic crustaceans; J. McMurrich - sea anemones; I. Oldroyd - molluscs; W. Thompson - bivalves and other invertebrates) (Bartsch 1921; Johnstone 1977). Thompson (1914 a) described some shellfish beds of Haida Gwaii and noted the high productivity in Burnaby Narrows that supported a clam cannery in nearby Bag Harbour. He also assessed the abundance and absence of abalone around Haida Gwaii (Thompson 1914 b).

The University of British Columbia (UBC) opened in 1915 and from the beginning the Zoology Department had close connections with the Pacific Biological Station. For example, C. McLean Fraser, Director of the Pacific Biological Station, became head of Zoology at UBC. The same pattern occurred subsequently with W. Clemens. In 1917 C. and E. Berkley came to the Pacific Biological Station as volunteers and they published a number of new records of polychaetes from Haida Gwaii (e.g., Berkeley and Berkeley 1942). Professor C. O'Donoghue, from the University of Manitoba and his wife, Elsie, visited the Pacific Biological Station in 1919 and worked on nudibranchs and bryozoans, some of which were from Haida Gwaii.

It took almost 60 years after George Dawson before there was another major investigation of local marine invertebrates. In the summer of 1935, C. McLean Fraser was aboard the hydrographic vessel *Wm. J. Stewart* collecting intertidal and offshore specimens. The localities for most subtidal stations are recorded in Bernard *et al.* (1967) and are in our database. Some records were soon published (e.g., Fraser 1936 a, b, 1942 a; Berkeley and Berkeley 1942), others were not published until later (Austin and Haylock 1973) and some material remains unworked. Fraser's (1938) field observations provided the first account of marine habitats around Haida Gwaii since those of Dawson (1880). He noted the abundance and diversity of species in oceanic passes with strong tidal currents (Houston Stewart Channel, Langara Island, Kerouard Islands) and commented that *"...of the shore line of the open coast that portion of it that is exposed to the full force of the ocean surf, is wholly barren, as no animals can stand the buffeting of the surf against the rocks in stormy weather."* However, recent observations have shown that even on the most highly wave exposed rocks on the west coast of Moresby Island certain species are abundant (Harper *et al.* 1994; Sloan and Bartier 2000).

Fraser (1942 a) noted that the second world war *"... has tended to put a quietus upon marine investigation. Expeditions far afield have been out of the question"*. In June and July of 1946, Ed Ricketts, a well known marine naturalist and author of the classic *Between Pacific Tides*, collected in the Masset area. Hedgpeth (1978) published Ricketts' correspondence with John Steinbeck that included the Haida Gwaii visit. Sadly, Ricketts died before his proposed book on northern coastal life was completed. Ricketts' technical field notes, including those from Haida Gwaii, are in the library of Stanford University, CA. Copies were kindly provided to us by R. Kool (British Columbia Ministry of Environment) and their species records are included in our data base. Ricketts' notes are sufficiently detailed that one could make comparative surveys in the same areas today. Ricketts did learn at least one new thing during his trip: *"I have often wondered if octopi ever used their sharp and strong beak to nip a person. Today I found out."*

The Russian research vessel *Vityaz* began major oceanographic investigations in the Pacific Ocean in 1949 which continued for many years (AS-USSR 1973). A cruise in 1958 brought them within a few km of the west coast of Haida Gwaii (Bernard *et al.* 1967). Some of the species records collected by the *Vityaz* are included in our database. For some years the Institute of Oceanography, UBC received ship time from the Defence Research Board of Canada to execute oceanography cruises. In 1953 R.F. Scagel and F.G. Barber circumnavigated Haida Gwaii on such a cruise during which 32 pelagic copepod species were identified (Cameron 1957).

The National Museum of Natural Sciences (now - Canadian Museum of Nature) staff visited the British Columbia coast to collect marine invertebrates and in the summer of 1957 they concentrated on Haida Gwaii (Bousfield 1958, 1963). He provided general habitat data for 70 stations. Some of this material has been worked up by Bousfield (gammarid amphipods), Rafi (isopods), Laubitz (caprellid amphipods), Mills (gammarid amhipods, Holmquist (mysids), and Hart (decapods) (Bousfield and Jarrett 1981). The British Columbia Provincial Museum (now - Royal British Columbia Museum) also worked on Haida Gwaii material (Hart 1940, 1953). Mr. P. Henson of Masset, collected along the coast of Graham Island and provided some of his records to UBC (mollusks - McTaggart Cowan 1964) and to the Pacific Biological Station (shrimp - Butler 1964).

D.B. Quayle (Pacific Biological Station) kept records of invertebrates in his field notes and some of these unpublished records from Haida Gwaii are included in our database. In addition, Quayle instituted a program of qualitative surveys of marine invertebrates in British Columbia in 1960. These surveys as well as other records from 1878 to 1972 together with notations of dominant major taxa are published (Bernard *et al.* 1967, 1968, 1970; Bernard and Quayle 1973). These reports include many from the Haida Gwaii region, illustrated later. Species records for some taxa have been worked up (Bernard 1967 b, 1971 - molluscs and brachiopods; Austin and Haylock 1973 - ophiuroids; Lambert 1978, 1984 – seastars and sea cucumbers; Butler, 1980 – shrimp; Brinckmann-Voss 1974, 1983 – jellyfish and hydroids). Unworked material remains at the Royal British Columbia Museum and the Canadian Museum of Nature.

In 1976 the Centre for Continuing Education (UBC) initiated field study cruises to Haida Gwaii. W.C. Austin recorded intertidal and subtidal species observed along the coast over the 12 years of these cruises. New records up to 1985 are included in Austin (1985) and the detailed records are included in our database. The British Columbia Provincial Museum staff have collected in intertidal and subtidal communities near Langara Island, in Rennell and Tasu Sounds, and at Cape St. James in 1976 and some of this material is in our database. Neil McDaniel collected and photographed a number of species including some new distribution records in 1983. These were reviewed and are in our database.

Concerns over industrial pollution effects on the Haida Gwaii marine environment has led to agency and industry reports that include information on marine invertebrates. The Environmental Protection Service reported on a benthic survey in Tasu Sound to assess impacts from submarine discharge of mine tailings [crushed ore from the processing mill] (Brothers, 1978). TEC (1992) and AMR (1997) described benthic biota at proposed coastal development sites in Queen Charlotte City and Rose Harbour respectively. Oil companies have sought approval to explore for oil and gas in Hecate Strait waters. Petro Canada and Chevron compiled Initial Environmental Evaluations (IEEs) on resuming exploratory activity, but these provide little specific information on non-commercial marine invertebrates (Anonymous 1982, 1983).

Surveys of commercial invertebrates are discussed later in this report. However, such surveys sometimes included information on non-commercial species. For example, Breen and Adkins (1975) note the occurrence of invertebrate species during SCUBA surveys of northern abalone (*Haliotis kamtschatkana*) and red sea urchin (*Strongylocentrotus franciscanus*) populations.

For example, Breen and Adkins (1975) note the occurrence of invertebrate species during SCUBA surveys of northern abalone (*Haliotis kamtschatkana*) and red sea urchin (*Strongylocentrotus franciscanus*) populations. Bernard (1979, 1981) listed invertebrates from the stomach contents of Hecate Strait Dungeness crab (*Cancer magister*). Jenkins and Britt (1972) recorded some of the invertebrates during a kelp survey. Also, DFO did surveys in four areas of Hecate Strait to assess benthic productivity (Burd and Brinkhurst 1987); their >500 species are in our database.

The Islands Protection Society sponsored several reports incorporating information on marine invertebrates. Reimchen (1984) compiled species lists for various habitats based on surveys and Denning (1984) wrote on rocky intertidal life. Stewart (1977/1980) recorded subtidal invertebrates for the British Columbia Ecological Reserves Program. Invertebrates were also recorded in reports commissioned by Parks Canada in preparation for Gwaii Haanas (Adkins 1977; Searing and English 1983; Searing 1987).

In 1988 the governments of Canada and British Columbia signed the *South Moresby Agreement* to establish a Gwaii Haanas national park reserve and demarcated a proposed national marine conservation area. This initiated a detailed biophysical inventory of coastal marine habitats in 1992 that included 104 intertidal stations around Gwaii Haanas resulting in a total of 362 species of invertebrates (Harper *et al.* 1994). Additional intertidal and subtidal inventories were carried out in Burnaby Narrows and Murchison-Faraday Passage (TEC/HFP, 1993, 1994). More recently the Geological Survey of Canada mounted a series of subtidal habitat surveys including grab samples that were analyzed and are incorporated in our database. As well, surveys on the Hecate Strait sponge bioherms and continental slope fauna were done and are reported below.

With a few exceptions, such as a subtidal Ecological Reserve (No. 67) for a soft sediment community in Satellite Channel, Gulf Islands, Strait of Georgia (established 1975), it was not until the 1990s that conserving British Columbia marine invertebrate biodiversity within an ecosystem context began to appear (Lambert 1994; Hawkes 1994). We have been slow to embrace new thinking about protecting our marine biodiversity heritage.

REGIONAL MARINE INVERTEBRATE SPECIES BIODIVERSITY

We started the invertebrate database with the Biophysical Inventory of Coastal

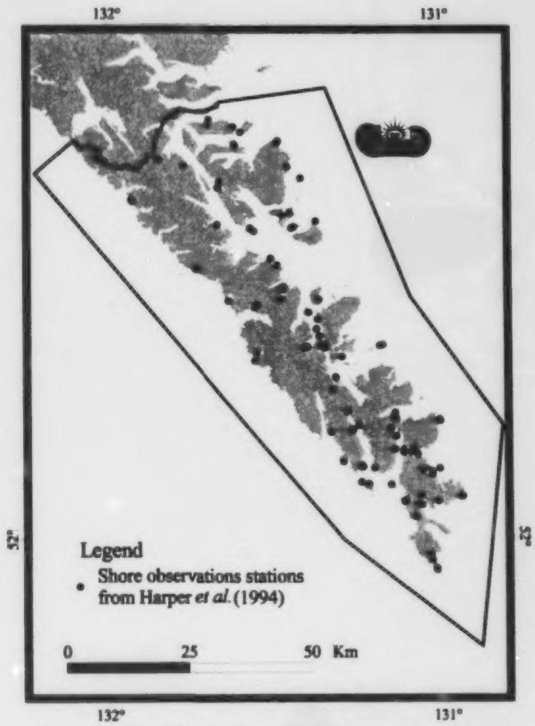


Figure 5. The 104 shore observation locations from which marine invertebrate data were recorded in the coastal biophysical inventory of Gwaii Haanas in 1992 by Harper *et al.* (1994).

Resources (Harper *et al.* 1994) with species observations from its shore observation stations in Gwaii Haanas illustrated in Figure 5. Figure 6 contains sample sites in the Gwaii Haanas area from two other surveys also commissioned in the 1980s in preparation for the establishment of Gwaii Haanas marine conservation area.

The sampling locations from selected marine surveys are illustrated in Figures 7, 8, 9 and 10. These maps geofererence some regional marine zoological history and are based on the original cruise descriptions. Figure 7 is of nearshore locations sampled between 1878 (Dawson 1880) and 1957 (Bousfield 1958). Some of these locations were already mapped, some were derived from secondary sources such as Bernard *et al.* (1967) for Dawson's work and some were extracted from the reports' texts. Some were surveyed by one person (e.g., C.F. Newcombe) with the resulting collections described by other specialists. Checking was essential, for example, Bernard *et al.* (1967) illustrated some of Dawson's locations, but missed others - which are included here. Other errors include Bousfield's (1958) Figure 2 that shows Gowgaia Bay as Tasu Sound, but describes his Tasu Sound locations correctly. The point is that we checked before committing historical locations to the GIS. Figure 8 contains the nearshore sample locations from cruises in the 1960s to the 1990s. These figures reveal that the north and east nearshore areas of Haida Gwaii tended to receive more benthic sampling than the more exposed west coast. The offshore (continental shelf and high seas) pelagic and benthic sampling shown in Figure 9 is from early U.S. (*Albatross*) and Soviet-era Russian (*Vityaz*) science cruises as well as more recent U.S., international and Canadian cruises associated with fisheries and pure research. Canada had a minor role in early high seas biological surveys, but a major role nearshore and on the continental shelf. Illustrated in Figure 10 are the dredging records from 1878 to 1972 from this region compiled by DFO.

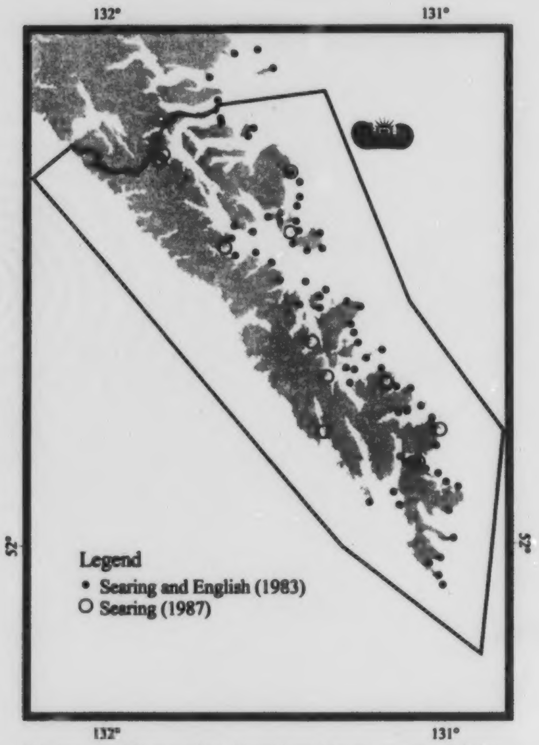


Figure 6. Observation locations from surveys of the Gwaii Haanas area commissioned by Environment Canada - Parks in the 1980s.

Regional reports such as Adkins (1977), that have general species lists but no specific locality data, were excluded. Further, many records were encountered from collections or literature in which vague geographic descriptions were described as: off the coast of British Columbia / Gulf of Alaska / Northeast Pacific / Northwest coast of Canada / Northwest coast of North America / along the coast from Alaska to California. These were also excluded from our database. Finally, the first regional attempt at linking coastal databases with digital mapping (MacLaren Plansearch 1987), was of no value as it included meagre data on only nine (commercially fished) invertebrate species.

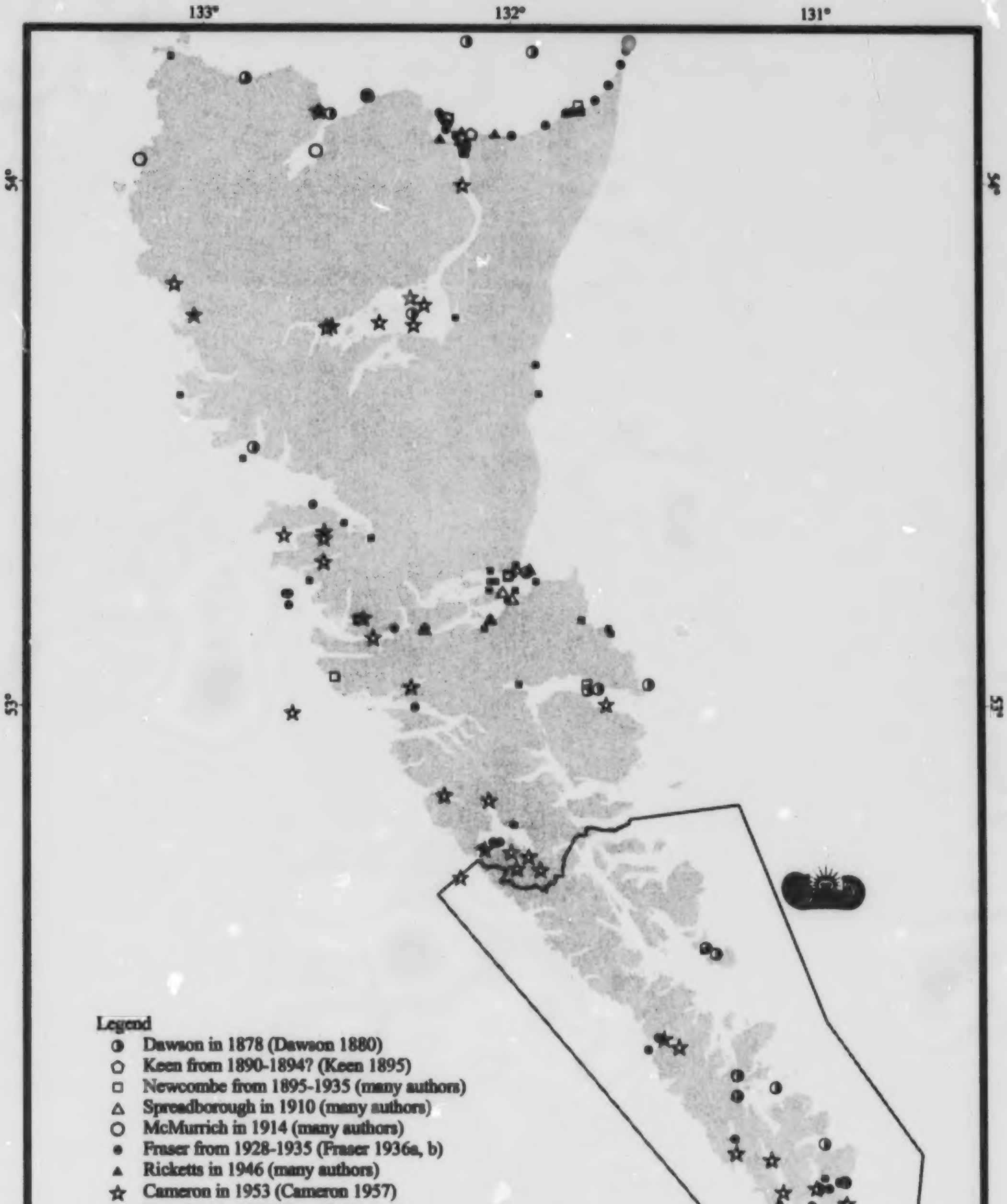

133°
132°
131°
54°
53°
52°
Legend
◑ Dawson in 1878 (Dawson 1880)
⬠ Keen from 1890-1894? (Keen 1895)
□ Newcombe from 1895-1935 (many authors)
△ Spreadborough in 1910 (many authors)
○ McMurrich in 1914 (many authors)
● Fraser from 1928-1935 (Fraser 1936a, b)
▲ Ricketts in 1946 (many authors)
☆ Cameron in 1953 (Cameron 1957)
▪ Bousfield in 1957 (Bousfield 1963)
25 0 25 50 Km

Figure 7. Sample locations of nearshore Haida Gwaii region marine surveys from which marine invertebrates were reported - 1878-1957.

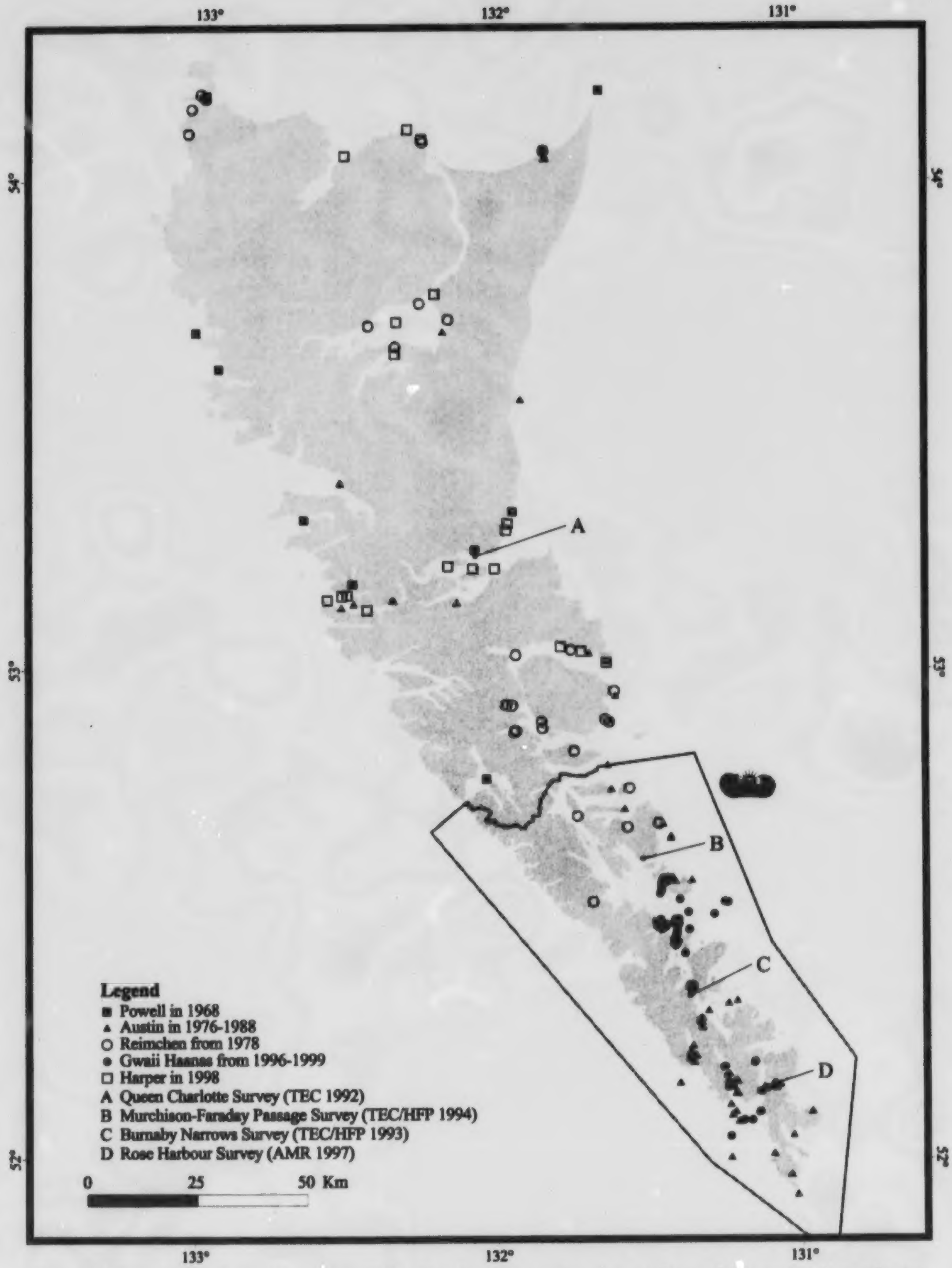

133°
132°
131°
54°
53°
52°
A
B
C
D
Legend
■ Powell in 1968
▲ Austin in 1976-1988
○ Reimchen from 1978
● Gwaii Haanas from 1996-1999
□ Harper in 1998
A Queen Charlotte Survey (TEC 1992)
B Murchison-Faraday Passage Survey (TEC/HFP 1994)
C Burnaby Narrows Survey (TEC/HFP 1993)
D Rose Harbour Survey (AMR 1997)
0 25 50 Km

Figure 8. Sample locations of nearshore Haida Gwaii region marine surveys from which marine invertebrates were reported - 1958-1999.

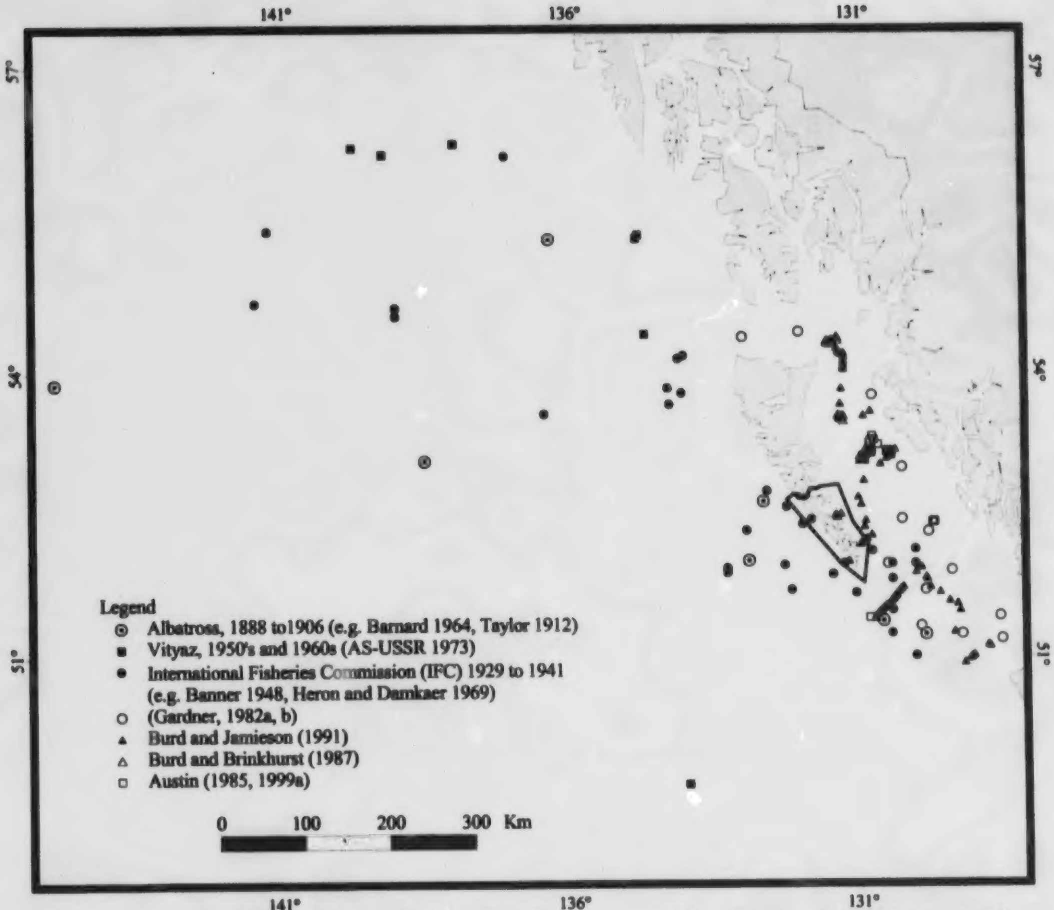
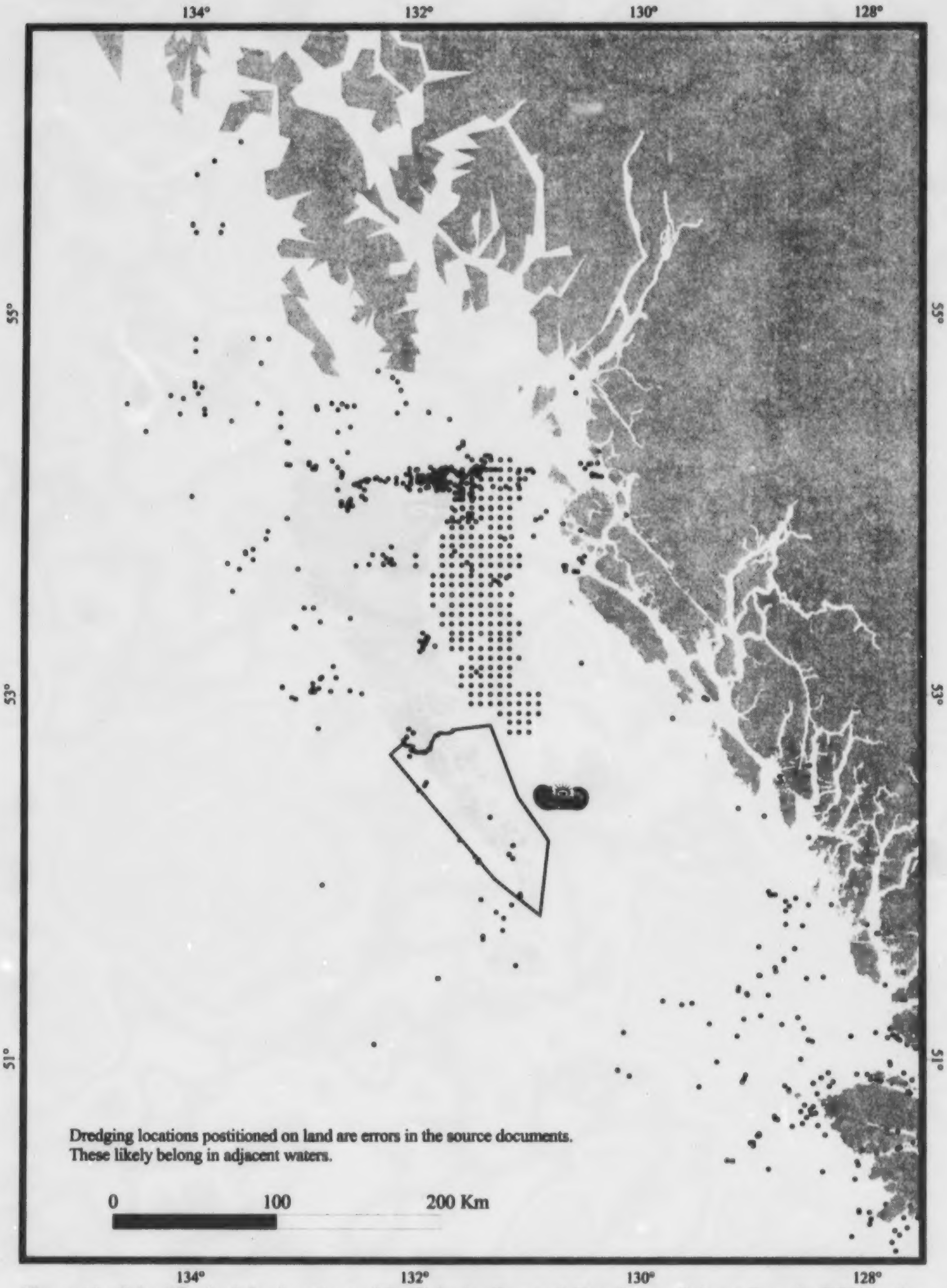

141°
136°
131°
57°
54°
51°
Legend
⊙ Albatross, 1888 to1906 (e.g. Barnard 1964, Taylor 1912)
■ Vityaz, 1950's and 1960s (AS-USSR 1973)
● International Fisheries Commission (IFC) 1929 to 1941 (e.g. Banner 1948, Heron and Damkaer 1969)
○ (Gardner, 1982a, b)
▲ Burd and Jamieson (1991)
△ Burd and Brinkhurst (1987)
□ Austin (1985, 1999a)
0 100 200 300 Km

Figure 9. Sample locations of offshore (continental shelf to deep-sea) Haida Gwaii region marine surveys from which marine invertebrates were reported - 1888 to 1999. The International Fisheries Commission (established in 1924) was renamed the International Pacific Halibut Commission in 1953.

The marine invertebrate species (or coarsely identified specimens to the family or genus levels) recorded from the Haida Gwaii region are listed in Appendix D. Species, and their taxonomic authorities (their first describers and namers), are listed according to their higher systematic groupings, starting with the phylum to which they belong. The 23 phyla are ordered, from simple to advanced, according to zoological convention; starting with the sponges (Porifera) and ending with the protochordate acorn worms (Hemichordata). At the superfamily designation and above, the higher taxonomic levels (e.g., class and order) are listed in conventional order as typified by listings such as Austin (1985) and Kozloff (1996). Below the superfamily level, the taxonomic levels are listed alphabetically. In keeping with taxonomic convention, the authorities of species names are bracketed if the genus within which the species is currently grouped is



Dredging locations postitioned on land are errors in the source documents. These likely belong in adjacent waters.

Figure 10. Scientific dredging locations of the Fisheries Research Board (now Science Branch, DFO) in the Haida Gwaii region, 1960 to 1972 (from Bernard *et al.* 1967, 1968, 1970; Bernard and Quayle 1973).

different from the genus to which that species was assigned when it was first described and named.

Next, the number of records of that class, genus or species in the database is given. The numbers relate to the geographic locations of records and the time of records. These records may be based on observations alone or supported by voucher (reference) specimens. For example, if a species was collected at the same place twice (e.g., in 1910 and 1990), that creates two observations in the database. Also, if a species was collected from two depths at one geographic location on the same day, that warranted two observations in the database. There are, therefore, four dimensions in the database (latitude, longitude, depth, time).

Museum codes are provided in the cases where specimens from the region are held in collections. This locates where the taxonomic reference materials are held and are, presumably, available for future analyses. Where the incompletely identified (class-level or genus-level) material is in a collection, this is a useful designation for taxonomists to easily locate the repositories of such specimens for future research. There is plenty of incompletely worked Haida Gwaii region material in museums.

Finally, the numbers in the far right-hand column link the references (literature citations) in which the genera or species are mentioned for the Haida Gwaii region. These numbers link the source literature, upon which the database is founded, to the observations and enables access to the scattered published science knowledge over the last ≈120 years. The references came from various types of published literature ranging from peer-reviewed journal articles and monographs (the "primary" literature) to "grey" or "secondary" literature sources of government documents and consultants' reports. As these references are important to identify, but are not cited in the text of this report, their full bibliographic citations are listed separately in Appendix E.

So, what is the value of this database? We see it as a starting point; a foundation to build upon. Although incomplete, the database likely represents ≈90% or our currently known marine animal species biodiversity. Corrections and new data can now be easily added. A wide range of sophisticated inquiries involving time and space can be made. The database can be used both as a tool for scientific inquiry and for application to management objectives, with some examples as follows:

- to overlay invertebrate knowledge on other GIS layers such as substrate type, depth contours, current patterns, etc. as a crude first step in putting assemblages of species into an ecological context;
- to refine or modify models of zoogeographic Northeast Pacific distribution patterns;
- to be the baseline for future re-surveying to assess faunal changes over time due to natural or human influences; and
- to identify regions with unusual or unique groups of species warranting protection.

The spatio-temporal GIS database consists of ≈2,500 species from 23 phyla comprising a total of 25,000 records from ≈2,900 different sample locations. The number of species in each phylum for the whole northeast Pacific, the entire British Columbia coast and the Haida Gwaii region are listed in Table 7. The varying proportions of the total British Columbia fauna represented by the Haida Gwaii fauna likely reflect incomplete sampling. All the sample locations are illustrated in Figure 11. Multiple sample depths, or samples from different times, at individual

Table 7. Number of marine invertebrate species from the Northeast Pacific area, whole British Columbia coast and the Haida Gwaii region listed according to phylum.

Phylum	Cold Temperate Northeast Pacific[1]	Whole British Columbia Coast[1]	Haida Gwaii Region[2]
Porifera (Sponges)	291	273	87
Cnidaria (Jellyfishes, Sea Anemones, Corals)	493	340	219
Ctenophora (Comb Jellies)	20	16	4
Platyhelminthes (Flat Worms)	126	65	73
Gnathostomulida	2	1	0
Nemertea (Ribbon Worms)	86	56	19
Nematoda (Round Worms)	175	120	31
Gastrotricha	9	9	1
Kinorhyncha (Snout Movers)	7	7	0
Priapulida	1	1	1
Acanthocephala	?	?	12
Annelida (Segmented Worms)	949	616	359
Echiura	18	3	4
Sipuncula (Peanut Worms)	21	9	11
Pogonophora (Beard Worms)	13	7	5
Mollusca (Snails, Clams, Chitons, Squids)	1471	785	560
Tardigrada (Water Bears)	5	5	0
Arthropoda (Crustaceans, Insects, Arachnids)	2103	1684	745
Phoronida	6	4	2
Brachiopoda (Lamp Shells)	16	10	8
Entoprocta	15	12	3
Rotifera (Wheel Animals)	10	10	0
Bryozoa (Moss Animals)	276	230	153
Echinodermata (Sea Stars, Sea Urchins, Sea Cucumbers, Sea Lillies, Brittle Stars)	281	180	158
Chaetognatha (Arrow Worms)	18	6	5
Urochordata (Tunicates, Salps)	96	76	42
Hemichordata (Acorn Worms)	8	6	1
Totals	6517	4532	2503

1 W.C. Austin (1985) and unpublished observations, Austin did not include endoparasites.

2 Our estimates are conservative as three types of observation were excluded: (1) we only included observations at the genus or family level when there were no species attributed to that genus or that family; (2) we excluded taxa whose identification was questionable, *i.e.* those that were accompanied by the "?" in Appendix D and; (3) we excluded the species with the cf. designation if there also was the same species but without the cf. designation.

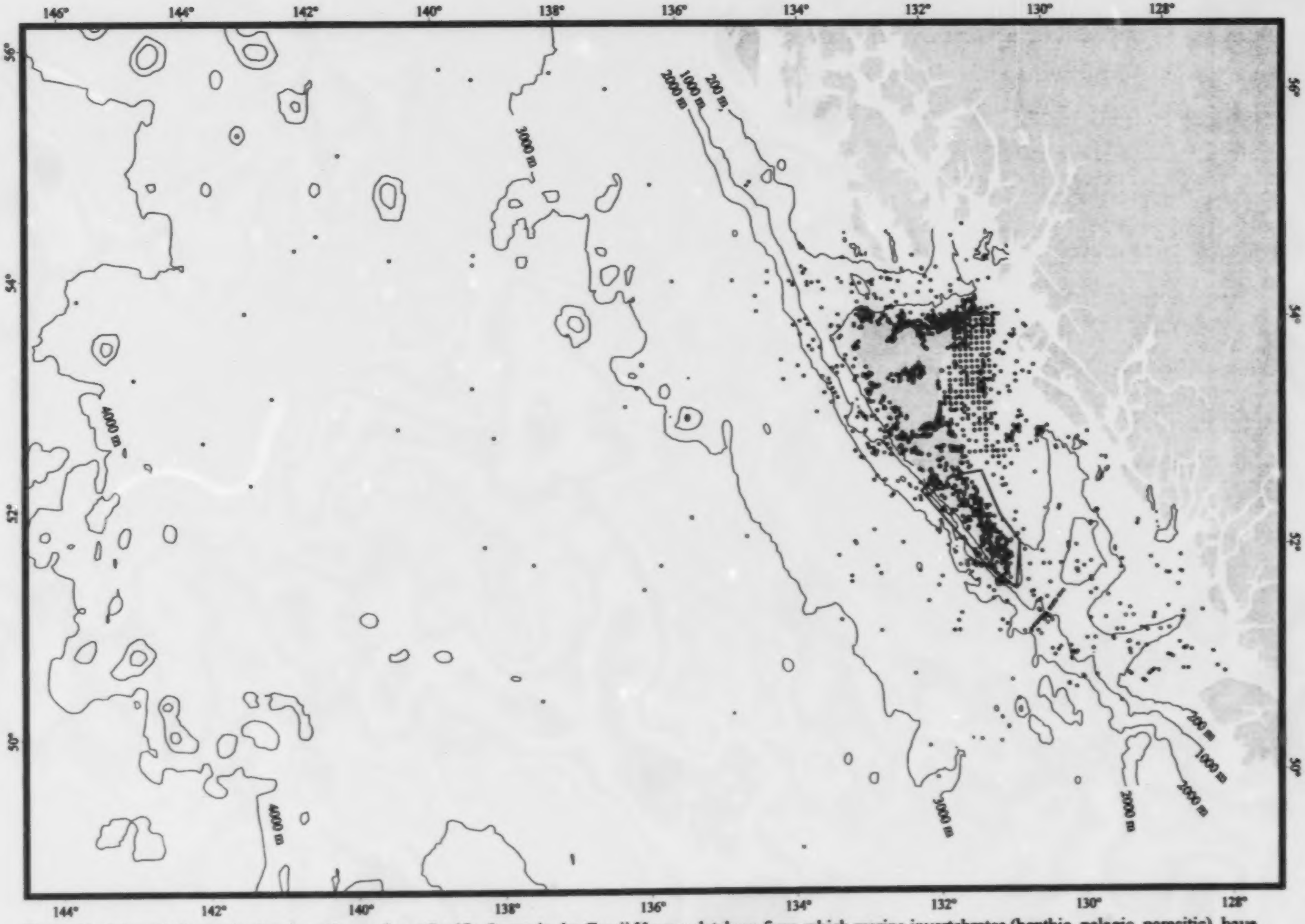


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Figure 11. Map of all sample sites from the northeast Pacific Ocean in the Gwaii Haanas database from which marine invertebrates (benthic, pelagic, parasitic) have been reported. The continental shelf edge (200 m isobath) and other depth contours to 4,000 m are shown.

locations are represented by one dot. Most sampling (≈80%) occurred in waters shallower than 200 m, that is, on the continental shelf or from inshore waters. Within continental shelf waters, Hecate Strait and Dixon Entrance have been much more sampled than the narrow shelf area off the west coast of Haida Gwaii. This compares to Tunnicliffe (1993), who estimated 3771 marine invertebrate species representing 25 phyla from all of British Columbia's marine waters. Tunnicliffe stated that British Columbia accounts for ≈3 to 4% of the world's marine invertebrate fauna and ≈2 to 4% of the world's coast. She stated that this similarity could reflect the temperate (mid-way between polar to tropical) position of the British Columbia coast.

Among the species in our database, 18 are reported only from the Haida Gwaii region (Table 8). We do not assume, however, that these are endemic (native only to our region) species, but rather this could be an artifact of the sporadic collecting along much of the Northeast Pacific coast. Because of the openness and water movement dynamics of the sea, endemism is often considered less common in the sea than on the land. Having stated that, however, endemism can occur in temperate areas particularly where latitudinal temperature gradients are steep or where species enjoy a refuge from major environmental changes (Norse 1993). Further, Norse (1993) stressed that it is important to identify marine areas rich in endemics and to know what types of marine ecosystems are particularly likely to have endemic species. An example of a possibly endemic marine species is the mysid crustacean *Holmesimysis nudensis*, which has been found repeatedly off Yakan Point, but not from many other northeast Pacific sample sites (Holmquist 1979). In summary, it is too early in our regional knowledge gathering to state how rich Haida Gwaii may be in having endemic marine invertebrates, but this is a possibility not to be overlooked as our database grows.

Sixteen invertebrate species from this region currently have special conservation status. Provided in Table 9 are the species "listed" at the Conservation Data Centre, Victoria, B.C.

Listed in Appendix F are the 101 species that were first described (and named) for science from material collected in the Haida Gwaii region. The specimens are collectively called "*type*" specimens and the Haida Gwaii region is, therefore, these species' "*type locality*." These species include those listed in Table 8 plus those that have been reported from other regions after having been first described from Haida Gwaii samples. For example, Lambert (1986) described a large new sea cucumber species (*Parastichopus leukothele*) from Tasu Sound, and knowledge of its range has since been extended to Point Conception, California (Lambert 1997). Gathering this sort of knowledge is a starting point to understanding what uniqueness Haida Gwaii's marine invertebrate fauna may represent.

The species list will be a work-in-progress for many years as there are large gaps in our knowledge. Whole ecosystems (e.g. estuaries) and habitat types are poorly sampled. As a more focused example, the habitat comprising the interstitial spaces between grains of sediment contains the meiofauna (animals that pass through a 0.5 mm sieve but are retained of a 0.05 mm mesh sieve), which has never been investigated in Haida Gwaii. There is much to be done and this sort of work is agreed among the experts to be a high marine conservation biology priority over the next decade (Hixon *et al.* 2001).

Table 8. Marine invertebrate species reported only from the Haida Gwaii region. All are confirmed as to the Haida Gwaii region being their type locality.

Species	Sources	Notes
Hydrozoa *Paulineum lineatum*	Brinckman-Voss and Arai (1998)	Collected from water column [0-550 m] off the west coast of Moresby Island, 1980
Sipunculid Worm *Nephasoma*[1] *wodjanizkii*	Murina (1973) *in Russian*	Collected from 1110 m off Dixon Entrance by the *Vityaz* in 1969
Bivalve *Cyclopecten carlottensis*	Bernard (1968)	Collected from 1450 m (1966) and 1650 m (1967) off the west coast of Moresby Island
Snail *Cocculina cowani*	McLean (1987)	Collected from 1370 m off the west coast of Moresby Island, 1966
Snail Fissurisepta pacifica	McTaggart Cowan (1969)	Collected from 860-878 m in Queen Charlotte Sound, 1964
Snail *Odostomia pharcida*	Dall and Bartsch (1907)	Collected from 18-27 m in Cumshewa Inlet, 1895
Isopod *Synidotea cornuta*	Rafi and Laubitz (1990)	Collected from the intertidal zone in Houston Stewart Channel, 1935
Isopod *Synidotea minuta*	Rafi and Laubitz (1990)	Collected from 2 intertidal sites on the west coast of Graham Island, 1957
Mysid *Holmesmysis nudensis*	Holmquist (1979)	Collected from the intertidal zone at Yakan Point in 1946 and again in 1957
Caprellid Amphipod *Pseudoliropis vanus*	Laubitz (1970)	Collected from 1100 m off Langara Island, 1965
Amphipod *Grandifoxus dixonensis*	Jarrett and Bousfield (1994)	Collected from 130-284 m in Dixon Entrance, 1965
Amphipod *Rhacotropis calceolata*	Bousfield and Hendrycks (1995)	Collected from water column [0-1227 m] off the west coast of Haida Gwaii, 1991
Amphipod *Rhacotropis americana*	Bousfield and Hendrycks (1995)	Collected from water column [0-1227 m] from 2 sites off the west coast of Haida Gwaii, 1991
Amphipod *Paramoera carlottensis*	Bousfield (1958) Staude (1986)	Collected from a stream mouth at Stiu Point, 1957
Pogonophoran Worm *Heptabranchia canadensis*	Ivanov (1962) *in Russian*	Collected from 2500-2600 m off the west coast of Haida Gwaii, 1958
Intertidal Beetle *Nebria charlottae*	Keen (1895) Kavanaugh (1989)	Collected from intertidal or supratidal sites near Masset, ≈1890
Intertidal Beetle *Nebria louisae*	Kavanaugh (1984, 1989)	Collected from the intertidal/supratidal zone at Skedans, Louise Island, 1981

[1] originally assigned to the genus *Golfingia*, the naming of which is an amusing bit of Victorian natural history: E.Ray Lankester (1885) named the creature, whose dissection he "*...carried out in the intervals of exercise with the club and ball sacred to the classic "green" of St. Andrews; and I have accordingly ventured to dedicate the new genus of Sipunculid worms indicated by this specimen to the local goddess whose cult is historically associated with the most ancient of Scottish seats of learning* (St. Andrews University – founded 1411)."

REGIONAL MARINE INVERTEBRATE BIOGEOGRAPHY

"*Indeed the Queen Charlotte Islands are, in a remarkable degree, the meeting-ground of northern and southern forms* (of bryozoa)."

"*We must, I think, make large allowance for the agency of man, and of currents, floating weed and timber, etc., in the diffusion of the species, apart from the general laws which preside over the distribution of life.*" (both Hincks 1884)

"*The enormous size of the ocean means that we need to consider separately patterns of diversity in the benthos of the shallow seas (essentially the continental shelves), the benthos of the deep-sea, and the plankton of the water column.*" (Clarke and Crame 1997)

Table 9. Marine invertebrate species from the Haida Gwaii region that have "listed" status at the Conservation Data Centre, Victoria, B.C.

Species	C.D.C. Status[1]
Sponge *Plocamissa igzo*	Red
Sponge *Chelonaplysilla polyraphis*	Red
Sea Anemone *Corallimorphus* spp.	Blue
Polychaete Worm *Hololepida magna*	Blue
Chiton *Hanleya oldroydi*	Red
Snail *Arctomelon stearnsii*	Red
Snail *Anidolyta spongotheras*	Red
Snail *Okenia vancouverensis*	Red
Snail *Calliostoma platinum*	Blue
Northern Abalone *Haliotis kamtschatkana*	Red[2]
Bivalve *Serripes groenlandicus*	Red
Bivalve *Rhamphidonta retifera*	Red
Intertidal Beetle *Nebria charlottae*	Red
Intertidal Beetle *Nebria louisae*	Red
Amphipod *Paramoera carlottensis*	Red
Sea Cucumber *Pentamera trachyplaca*	Red
Acorn Worm *Saccoglossus* spp.	Red

[1] Red = endangered / threatened
Blue = vulnerable

[2] will be red-listed by the CDC by early 2002 (S. Cannings, CDC, *personal communication*)

"*…habitat-level surrogates may be a highly cost-effective method for initial identification of high-priority areas to manage diversity of coastal ecosystems.*" (Ward *et al.* 1999)

"*…we advocate a major initiative to organize the spatial and temporal information on marine biodiversity that is already available, constructing databases that will be of immediate use for conservation efforts. Geographic information systems (GIS) mapping patterns of marine habitats and biodiversity will be especially valuable …*" (Hixon *et al.* 2001)

As invertebrates likely account for >90% of the region's marine animals, patterns of invertebrate-habitat relations underpin marine biogeographical generalizations, especially the benthos (bottom-dwelling species). Further, invertebrates tend to be more spatially persistent than the more mobile fishes. It is interesting that the insightful comments of Hincks (1884) still stand – with relatively little progress in the interim.

Broad-scale Northeast Pacific Marine Area Delineation

A brief overview of Northeast Pacific biogeographical schemes within which the Haida Gwaii region occurs is warranted. One approach to oceanic scale is the Large Marine Ecosystems concept intended to facilitate long-term, science-based sustainability for each region. These are sea spaces with distinct bathymetry (depth), hydrography (water movement), productivity and trophic (energy) relationships (Sherman and Duda 1999). Large Marine Ecosystems usually extend from watersheds to within the 200 nautical mile (≈320 km) Exclusive Economic Zone, and their boundaries are transitional – not

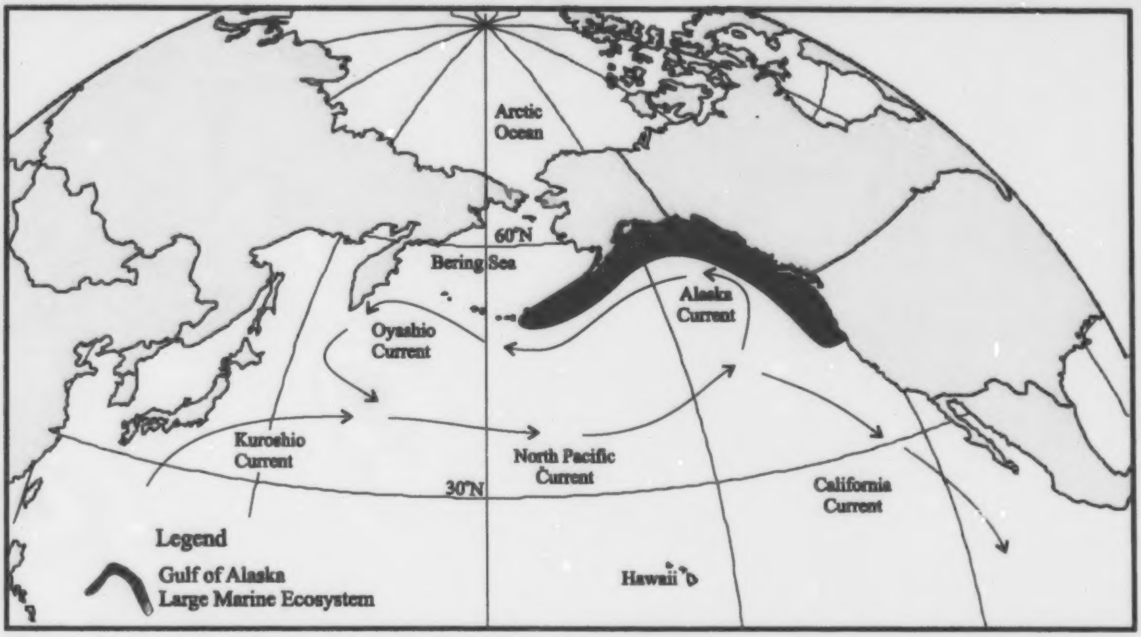


Figure 12. Map of the northeast Pacific showing boundaries of the Gulf of Alaska Large Marine Ecosystem (from Sherman 1994).

fixed. Globally, the 50 Large Marine Ecosystems identified account for ≈95% of the world's fisheries [http://www.edc.uri.edu/lme/].

The local Large Marine Ecosystem, called "*Gulf of Alaska*," extends approximately from north of the mouth of Columbia River to the Aleutian Islands extending off the Alaska Peninsula (Figure 12). This system is characterized oceanographically by the counter-clockwise gyre of the Alaska Current and incursions of colder Subarctic Current. The Canadian component of the Gulf of Alaska large marine ecosystem is currently being characterized by DFO (DFO 2000 a) and the U.S. National Marine Fisheries Service is investigating American components. These projects will provide an improved context for northeast Pacific ocean ecosystems.

Another broad biogeographic scheme involves marine faunal provinces. These have been discussed by fish and marine invertebrate systematists, such as Bernard *et al.* (1991) and Coan *et al.* (2000) for bivalve mollusks, Hobson and Banse (1981) for polychaete worms and Peden and Wilson (1976) for fishes. Haida Gwaii is within the cold temperate "*Oregonian*" province on the northeast Pacific. For bivalves, this province extends from ≈60° N at Nunivak Island, Alaska in the eastern Bering Sea south to Point Conception, CA (≈34.5° N). Point Conception demarcates the northern boundary of the warm temperate "*Californian*" province with the Oregonian province in virtually all zoogeographic studies (Bernard *et al.* 1991).

Although Point Conception demarcates so clearly in the south for most biogeographic studies, northern faunal limits vary according to organism group. For example, the Nunivak Island boundary clearly separates *Oregonian* from "*Arctic*" province bivalve species. Coan *et al.* (2000), in their thorough review, state that other studies recognize a faunal boundary off Dixon Entrance (≈54.5° N). For polychaetes

(Hobson and Banse 1981) and nearshore fishes (Peden and Wilson 1976) the northern *Oregonian* boundary has been set at Dixon Entrance. As well, the Entrance represents the southern extreme of the northern seaweed flora in the northeast Pacific (reviewed in Sloan and Bartier 2000). A pronounced oceanographic feature exists well seaward of Dixon Entrance focusing biogeographical interest in the area (Briggs 1974). Japanese currents combine and flow eastward across the north Pacific in the West Wind Drift along ≈40° N. At ≈500 km offshore this drift splits into the Alaska Current going northward to the Gulf of Alaska and the Bering Sea (Figure 12). The southern arm flows south as the California Current. Oceanographers divided the north Pacific into "*Domains*" in which the West Wind Drift and California Currents are called the "*Transitional Domain*" (Briggs 1974). These currents and the offshore oceanography of British Columbia and Haida Gwaii are thoroughly described by Thomson (1981, 1989). The important point is that the *Transitional Domain* may contribute to a significant biogeographic boundary occurring in the area of Dixon Entrance.

Another way to divide up the ocean is by Steele's (1998) "*sectors,*" discussed below in the context of British Columbia, as follows:

- Coastal Domain for which he claims there is "*.... no longer a choice between pristine and managed coastlines, but only between priorities for use*";
- Continental Shelf (50 to 200 m depth) "*.... where we catch nearly all of our fish as well as drill for oil* ", and where fisheries/ economic sustainability is not achieved; and
- Deep Ocean (seaward of the continental shelf) about which he claims is "*comparatively pristine.*"

British Columbia and Haida Gwaii Marine Ecosystem Delineation

To provide some context to British Columbia marine waters, Steele's sectors are compared in Table 10 to the local marine habitat types listed by Tunnicliffe (1993) and defined from the literature. This report deals with all sectors, but mostly with the coastal domain and continental shelf components of the Haida Gwaii region where most of the sampling occurred.

Physical oceanography provides important insights into differences within the Haida Gwaii region, especially to its marine biogeography. Reviews on regional oceanography and ocean data seta are provided in Thomson (1989), Nichol *et al.* (1993), Robinson *et al.* (1999) and Crawford (2000), so only a brief overview is presented here. Thomson (1989) divided the region's "*diverse oceanographic setting*" characterized by transition linking open ocean and coastal runoff processes into three oceanographic domains as follows:

- Oceanic – along the west coast where oceanic offshore processes dominate;
- Eastern Coastal – including Hecate Strait and Queen Charlotte Sound where offshore and estuarine processes are equally influential; and
- Northern Coastal – consisting of Dixon Entrance and adjoining channels in which runoff from large rivers (e.g., Nass and Skeena) yields estuarine flow patterns.

Thomson (1989) was emphatic, however, that comprehensive physical oceanographic knowledge of this very diverse region is rudimentary. He stated that: "*... we have a limited understanding of the basic spatial and temporal variability of the water properties and circulation.*" To this we would add that nearshore oceanography of the Haida Gwaii region is virtually undescribed and,

Table 10. Broad-brush ocean "*sectors*" as defined by Steele (1998) compared to the "*marine habitat*" types of British Columbia identified by Tunnicliffe (1993).

Steele's "*sectors*"	Tunnicliffe's "*marine habitats*"
Coastal Domain	Coastal Fjord[1]
Continental Shelf[2]	Inner Strait (e.g., Hecate Strait) Continental Slope/Shelf (shelf[2] component)
Deep Ocean	Continental Slope/Shelf (slope[2] component) Submarine Canyon[3] Ocean Ridge[4] Abyssal Plain[5] Seamount[6](e.g., Bowie Seamount[7]) Pelagic[8]

[1] a semi-enclosed, glacially-carved coastal inlet, usually steep-walled and deep with submarine sills formed by remnant glacial deposits (moraines) near their seaward ends ("mouths") connecting to the ocean and which isolate deep fjordic basins. Fjords are typically a specialized estuary as streams drain into their landward ends ("heads") creating lower-salinity (brackish) surface waters. They are common features of high-latitude mountainous coasts such as along the British Columbia mainland, Norway, Chile and southern New Zealand.

[2] a submarine coastal plain at the continental edge usually not deeper than 200 m and at whose seaward edge there is a sharp break in slope (continental slope) that declines steeply into the deep-sea proper. The base of the continental slope can occur at 2 to 4 km depth. The slope essentially demarcates the underlying boundary between the oceanic and continental crust.

[3] a fissure-like channel cut down the continental slope

[4] an area at the edge of dynamic plates at which crust is being formed (by spreading) or consumed (by subduction) and sometimes characterized by hydrothermal vents issuing super-heated, geothermal seawater with their attendant specialized faunas (Tunnicliffe *et al.* 1998). The Endeavour Hot Vents ≈250 km southwest of Vancouver Island at ≈2250 m depth are a DFO pilot Marine Protected Area under the *Oceans Act*.

[5] areas of relatively level deep-sea sedimentary bottom at ≈2 to 6 km depth

[6] inactive ocean-floor volcanoes that do not rise above sea level

[7] Bowie Seamount is located ≈180 km directly west of Rennell Sound, Haida Gwaii. It rises ≈3 km from the ocean floor to only 20 m depth and is a DFO pilot Marine Protected Area under the *Oceans Act*

[8] open water high seas

therefore, even less well understood than the larger-scale offshore oceanographic processes.

The previous zoological history section mentions the biogeographical generalizations for Haida Gwaii by C. McLean Fraser. Fraser (1942 b), a prominent marine ecologist in his day, declared that coast-wide; "*...only a comparatively small proportion of the 25,000 miles of tide water in British Columbia is well suited for animal habitation.*" This misleading generalization was based in part on his June-July, 1935 cruise in Haida Gwaii aboard the hydrographic vessel *Wm. J. Stewart* (Fraser 1936 a,b, 1938). His 1938 paper was the first attempt to synthesize marine faunal distributions according to habitat in Haida Gwaii. He reported that the richest (species and/or biomass?) faunal areas were those of greatest water mixing and sheltered, high tidal current narrows between islands. For pelagic species, headlands and capes (Langara Island and Cape St. James areas) associated with strong mixing of waters from different depths had the richest faunas. Next were the exposed entrances nearby major channels such as Houston Stewart Channel and Skidegate Inlet and exposed Fredrick and Hippa Islands. The least fauna-rich areas were those of exposed coasts between promontories and sheltered in inlets. Fraser (1938) called these *"intervening areas along the open coast"* between inlets and *"inner waters"* and *"inner shores of the inlets"* with *"poor and uninteresting"* faunas.

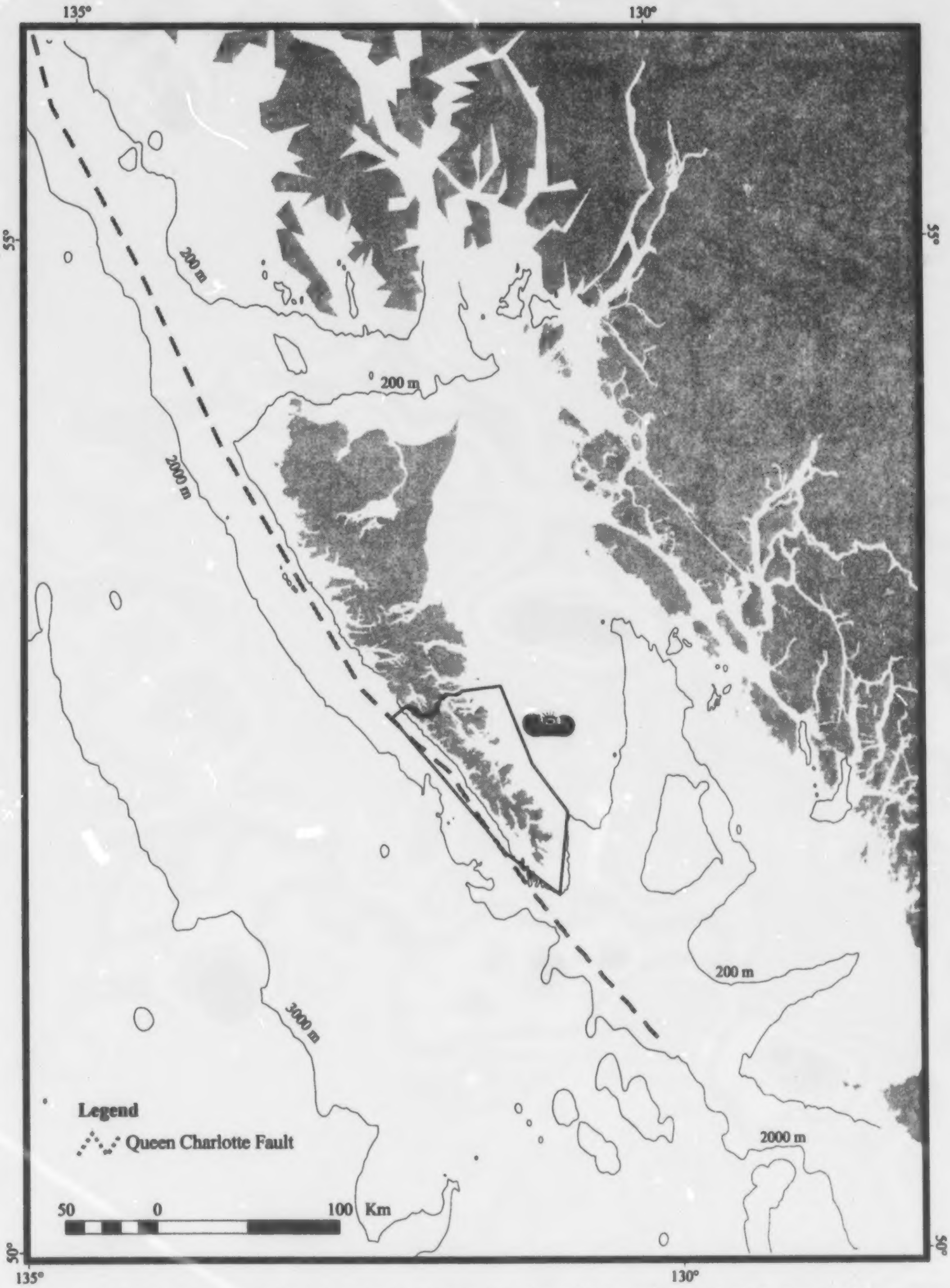
Within the coastal domain of Haida Gwaii, there are three fjord-like inlets with bedrock (not glacial deposit) sills; Tasu Sound (sill 110 m depth), Gowgaia Bay (sill 60 m) and Port Chanal (sill 40 m), as well as Rennell Sound - a large, unsilled inlet enclosing basins (Barrie and Conway 1996). The numerous glaciations of the Pleistocene era carved, but then filled, other inlets such as Masset Inlet so that they do not have deep basins isolated by submarine sills of glacial deposits that characterize true fjords.

The latter Pleistocene era glaciation events were weak for the Haida Gwaii region and apparently did not extend seaward of the San Christoval mountain range comprising the rugged western shores Moresby Island (J.V. Barrie, Geological Survey of Canada [NRCan], *personal communication*; Heusser 1989). The continental shelf area of Haida Gwaii has been proposed as an important coastal refugium from the last (Wisconsin) glaciation for both terrestrial biota and early humans of North America (Josenhans *et al.* 1995, 1997; Byun *et al.* 1999; Fedje and Christensen 1999). Byun *et al.* (1999) proposed that the Haida Gwaii refugium was likely one in a series of coastal refugia that were intermittently connected along Pacific North America through fluctuations in ice margins and sea levels.

Haida Gwaii and its continental shelf areas (<200 m depth - Figure 13) are one of the most seismically active areas in Canada (Barrie and Conway 1996). Haida Gwaii forms part of the leading edge of the westward-moving North American tectonic plate. The Pacific Plate is moving northward relative to the North American Plate a few cm annually. These plate movements created the San Christoval range and influence the continental shelf structure. Plate edges comprise the active Queen Charlotte Fault line shown in Figure 13 (Barrie and Conway 1996). The narrow (≈5 to 30 km) continental shelf off the west side of Haida Gwaii has a steep seaward decline (continental slope) descending to the deep ocean.

The Haida Gwaii region has also undergone dramatic sea level fluctuations as illustrated in Figure 14 (Josenhans *et al.* 1995, 1997; Fedje and Josenhans 2000). Early post-glacial shorelines were 150 to 200 m below the modern sea level position. The earliest well-constrained position is at 12,400 years BP when sea level was 150 m lower than today. Relatively rapid eustatic sea level rise (due to global ice melt) simultaneous with isostatic land depression near the edge of the Continental Shelf (due to rebound of the British Columbia mainland following the melting of continental ice) and minor tectonic uplift resulted in net sea level rise in the Haida Gwaii region. This marine transgression was rapid with sea level reaching that of the present shoreline ≈9,400 years BP and a Holocene maximum of 15 m above current levels by ≈8,900 years BP. Sea level remained high between 8,900 and 5,000 BP during which time relatively slow eustatic rise matched regional tectonic uplift. Eustatic rise became minor after 5,000 years BP and continuing tectonic uplift has resulted in slowly falling sea levels since that time.

The rapid marine inundation of coastal lowlands removed most of the alluvial (water-transported) postglacial sediment from the continental shelf along the west coast of Haida Gwaii, with the exception of Rennell Sound that contains pre-Holocene sediments in its inner basin (Barrie and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Legend
Queen Charlotte Fault
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100 Km
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50°
135°
130°

Figure 13. Depth contours (isobaths) of the Haida Gwaii region with the continental shelf edge at 200 m depth. Also illustrated is the Queen Charlotte Fault. Isobaths were generated from Canadian Hydrographic Service data.

Conway 1996). High energy wave action and tidal currents, along with limited new sediment coming off the rocky land, have *"left this dynamic coastline barren"* of sediment (Barrie and Conway 1996). The three silled inlets named above contain recent, fine, organic-rich sediments typical of fjords, and, with Rennell Sound, shelter sediments along the mostly rocky, sediment-poor continental shelf of the west coast of Haida Gwaii (Barrie and Conway 1996). Macdonald and Pedersen (1991) found little geochemistry knowledge of regional continental shelf sediments.

With the exception of forest harvest north of Gwaii Haanas, the dynamism and exposure of the continental shelf waters off Haida Gwaii combined with limited municipal wastes, modest levels of farming, no industrial mills and no current mining likely render local waters and sediments relatively unpolluted from terrestrial sources. This is very different than for southern British Columbia areas, such as the Strait of Georgia, where extensive upland human activities influence local (downstream) marine pollution levels.

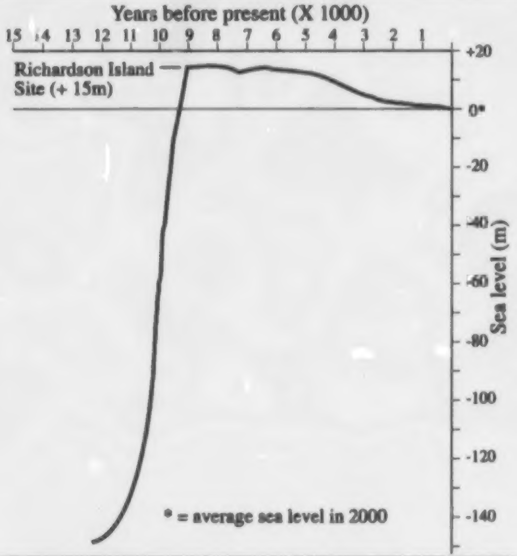


Figure 14. The relative sea level in the Gwaii Haanas area over the last 14,000 years; note the Richardson Island archaeological site of coastal human habitation (~9,000 years BP) is at 15 m above the current sea level (from Fedje and Christensen 1999).

The minority (≈20%) of sampling occurred seaward of the continental shelf in waters exceeding 200 m depth. The deep ocean habitats within the proposed Gwaii Haanas sea boundary include small amounts of pelagic, continental slope and perhaps some abyssal plain. The continental slope off Haida Gwaii has no large canyons, and ocean ridges and seamounts are far offshore (Table 10). The most important continental slope sampling occurred in summer 2000 during the trawl-swept survey for deep-water Tanner crab (*Chionoecetes* spp.) (J. Boutillier, DFO, *personal communication*). A summary of the sample locations and preliminary findings are provided below in the fisheries section. The unpublished, preliminary species data are also included in our database.

Protecting marine areas requires describing ecosystems by practical schemes and at appropriate scales (Levings *et al.* 1998). Watson (1998) reviewed the field of marine ecosystem classification systems world-wide and regionally using the delineation of marine ecosystems in the Strait of Georgia as an example. She recounted the development of the British Columbia Marine Ecosystem Classification System which is a five-tiered hierarchical scheme initiated by Environment Canada and adapted provincially by the British Columbia Land Use Coordination Office [now the Resource Planning Division, Ministry of Sustainable Resource Management] (Searing and Frith 1995; Zacharias *et al.* 1998; Zacharias and Howes 1998). The central idea is that the more observable abiotic characteristics of an area are easier to identify or measure than biotic

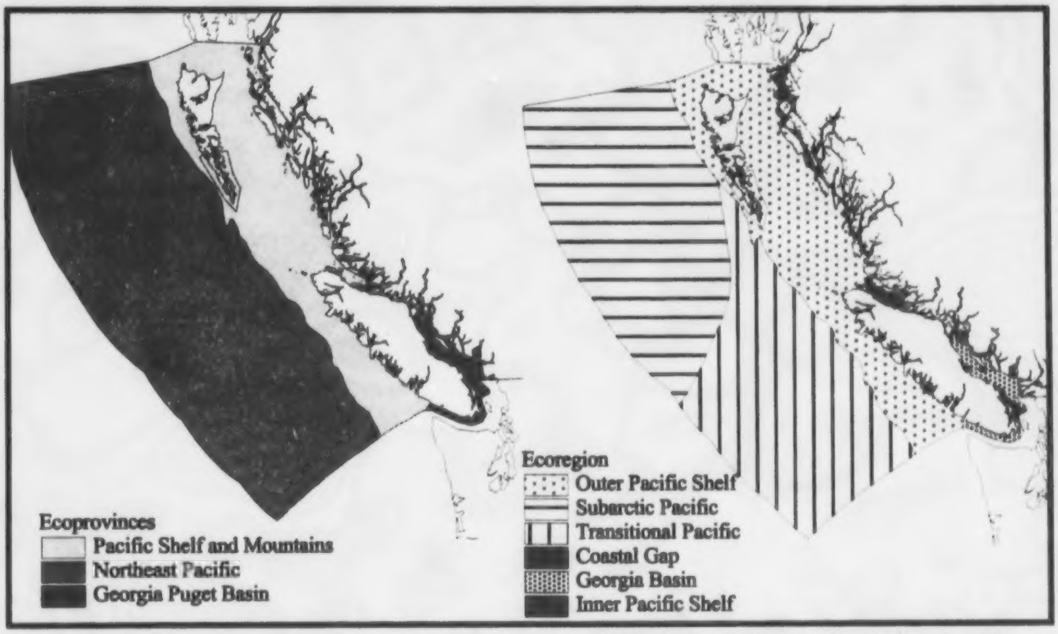


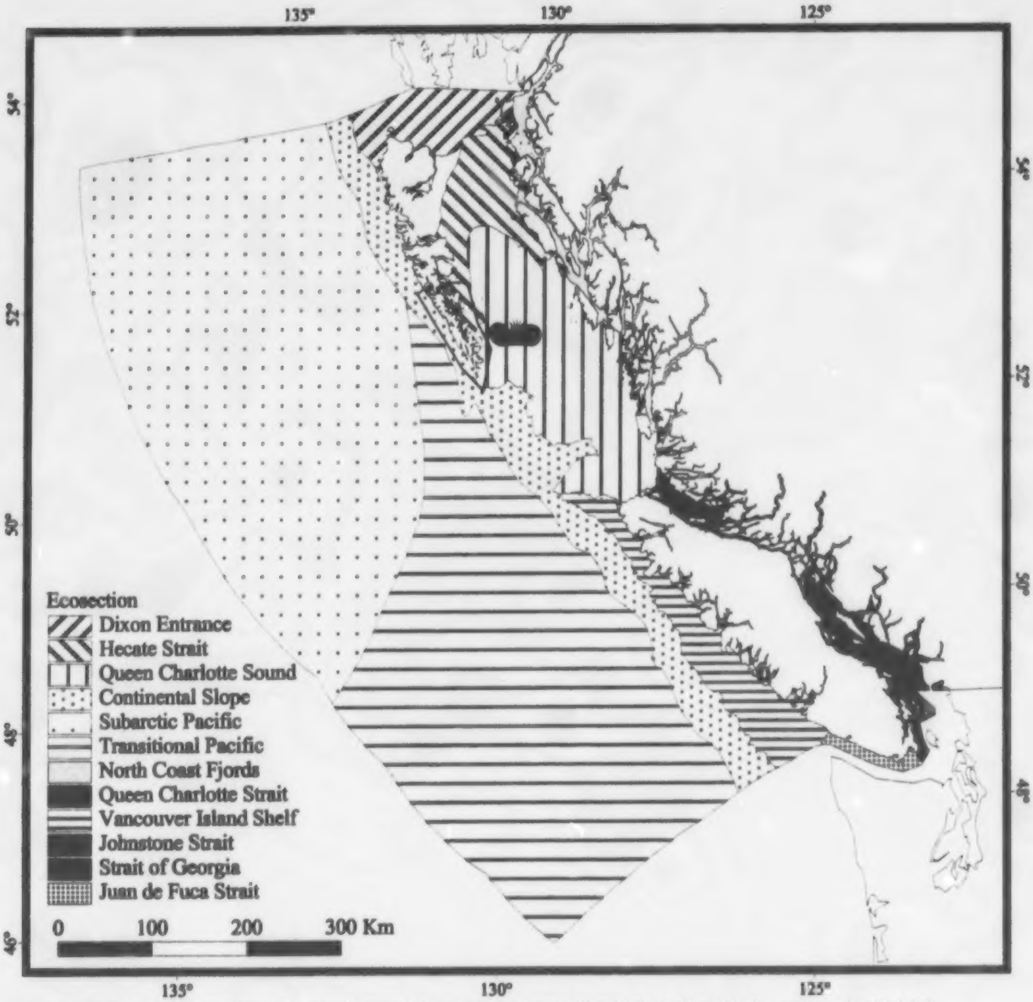
Figure 15. Pacific marine Ecoprovinces and Ecoregions of the whole coast of British Columbia based on the British Columbia Marine Ecosystem Classification System (from Zacharias *et al.* 1998).

components (Ward *et al.* 1999; Zacharias and Roff 2000).

The British Columbia scheme's three Pacific marine Ecoprovinces and six Ecoregions are illustrated for the entire British Columbia coast in Figure 15. Note the Subarctic Pacific and Transitional Pacific boundary offshore of Haida Gwaii. This split is also manifested in the 12 Ecosections for the coast illustrated in Figure 16 and whose justification criteria for the six Ecosections occurring in the Haida Gwaii region are listed in Table 11. Note that the boundaries and biotic characterization are not based on specific biotic communities, i.e., there is limited evidence presented that they are biogeographic areas. The diverging Alaska and California Currents separate the North American coast perhaps in important ways as Haida Gwaii appears to straddle the transition area between them.

The finest scale of this scheme divides up British Columbia's marine area into and 619 Ecounits. These are illustrated just for the north coast of British Columbia in Figure 17. The Ecounits were intended for use in marine area planning and management. They are subdivisions based on current regime, depth, exposure, substrate and sea bottom relief. Variables of seawater temperature and salinity are currently being added. The scheme yielded 65 Ecounit types, that is, different combinations of these five variables. Seven Ecounit types are unique in British Columbia, of which one (Masset Sound) is from Haida Gwaii (Zacharias and Howes 1998).

In the future, we hope to use the biotic information in our database to assess the inferences about biotic communities based on abiotic components. For example, does a given Ecounit type, based on a combination of abiotic variables, always represent the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46°
Ecosection
Dixon Entrance
Hecate Strait
Queen Charlotte Sound
Continental Slope
Subarctic Pacific
Transitional Pacific
North Coast Fjords
Queen Charlotte Strait
Vancouver Island Shelf
Johnstone Strait
Strait of Georgia
Juan de Fuca Strait
0
100
200
300 Km

Figure 16. Pacific marine Ecosections of the whole coast of British Columbia based on the British Columbia Marine Ecosystem Classification System (from Zacharias *et al.*1998).

same biotic community; and, conversely, does a particular biotic community always fit one Ecounit type?

The distributions of intertidal invertebrates have been widely used to characterize shore conditions such as exposure to wave energy, substrate type and substrate grade (Menge and Branch 2001). Listed in Table 12 are invertebrate species used by Harper *et al.* (1994) to discriminate community types from aerial photographs of Gwaii Haanas' shores. Illustrated in Figure 18 are the reported locations of the goose barnacle (*Pollicipes polymerus*) and the two algae species *Mazzaella cornucopiae* and *Alaria nana* around Haida Gwaii. These three species are reliable indicators of highly exposed rocky shores (Table 12; Sloan and Bartier 2000). Their absence from Haida Gwaii's northeast shore likely relates to lack of suitable rocky shores with less stable sand-to-boulder substrates in that area rather than the lack of exposure. Essentially, all exposed shores of Haida Gwaii are open-coast including its eastern shores along

Table 11. Pacific marine Ecosections of the Haida Gwaii region and their justification criteria according to the British Columbia Marine Ecosystem Classification System (from Zacharias *et al.* 1998).

Marine Ecosection	Physiographic Features	Oceanographic Features	Biological Features	Boundary Rationale
Dixon Entrance	Across-continental shelf trough with depths mostly <300 m; surrounded by low-lying coastal plains.	Strong freshwater influence from mainland river runoff drives NW-flowing coastal buoyancy current and estuarine-like circulation.	Mixture of neritic[1] and subpolar plankton species; salmonid migratory corridor; some productive and protected area for juvenile fishes and invertebrates.	Distinguished from area to south by strong freshwater discharge influence.
Hecate Strait	Very shallow continental shelf dominated by course bottom sediments; surrounding coastal lowlands.	Semi-protected waters with strong tidal currents that promote mixing; dominantly "marine" waters.	Neritic plankton communities with some oceanic intrusion; nursery area for salmon and herring; abundant benthic invertebrates ; feeding areas for marine mammals and birds.	Marine in nature but much shallower, with associated greater mixing, than areas to the south.
Queen Charlotte Sound	Wide, deep continental shelf characterized by several large banks and inter-bank channels.	Ocean wave exposures with depths mostly >200 m and dominated by oceanic water intrusions.	Mixture of neritic and oceanic plankton communities; northern limit for many temperate fish species; lower benthic production.	More oceanic (deep) and marine than Hecate Strait.
Continental Slope	Steep slope starting at the continental shelf edge descending into the deep-sea.	Strong across-slope and downslope turbidity (sediment-rich) currents.	Upwelling zone; productive coastal plankton communities and unique assemblages of benthic species.	Transition between continental slope and abyssal plain.
Subarctic Pacific	Includes abyssal plain and continental slope; a major transform fault occurs along the west margin and a seamount chain trends NW/SE	The E-flowing subarctic current bifurcates at coast with N-flowing Alaska Current; current flow is generally N throughout the year.	Summer feeding ground for salmonids; abundant pelagic fishes, e.g., pomfret, Pacific saury, albacore tuna and jack mackerel in summer, boreal plankton community.	The N and W boundaries are undefined. The E boundary is at the edge of the continental shelf. The S boundary is indistinct.
Transitional Pacific	Includes abyssal plain and continental slope; also includes spreading ridges, transform faults and plate subduction zone.	Area of variable currents; southerly areas may be affected by S-flowing California Current (summer) but remainder of area characterized by weak and variable currents; Davidson Current along shelf edge flow N in winter, S in summer.	Transition zone between southerly, temperate, and northerly boreal plankton communities; mixing of oceanic and coastal plankton communities adjacent to the continental shelf.	The N boundary is indistinct and approximately coincident with the S limit of the Alaskan Current (winter). The E boundary is at the edge of the continental shelf. The S and W boundaries are undefined.

[1] neritic means occurring in waters over the continental shelf (<200 m depth)

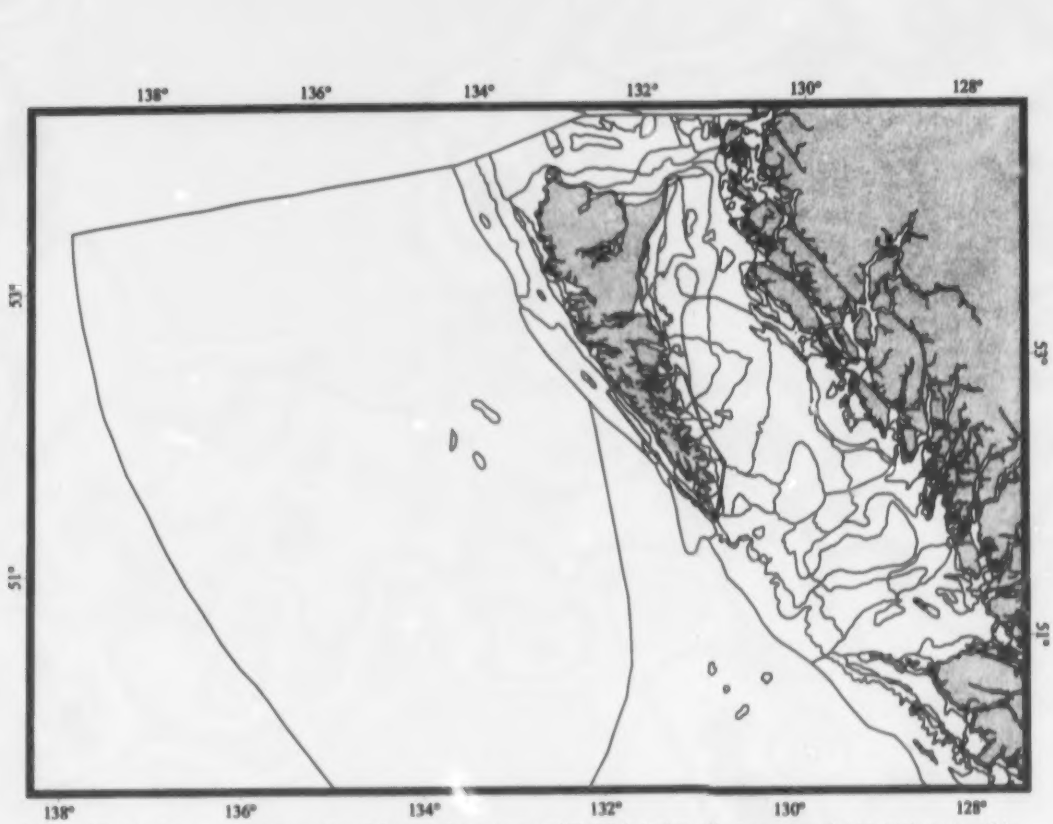
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Figure 17. Pacific marine Ecounits of the northern coast of British Columbia based on the British Columbia Marine Ecosystem Classification System (from Zacharias *et al.*1998).

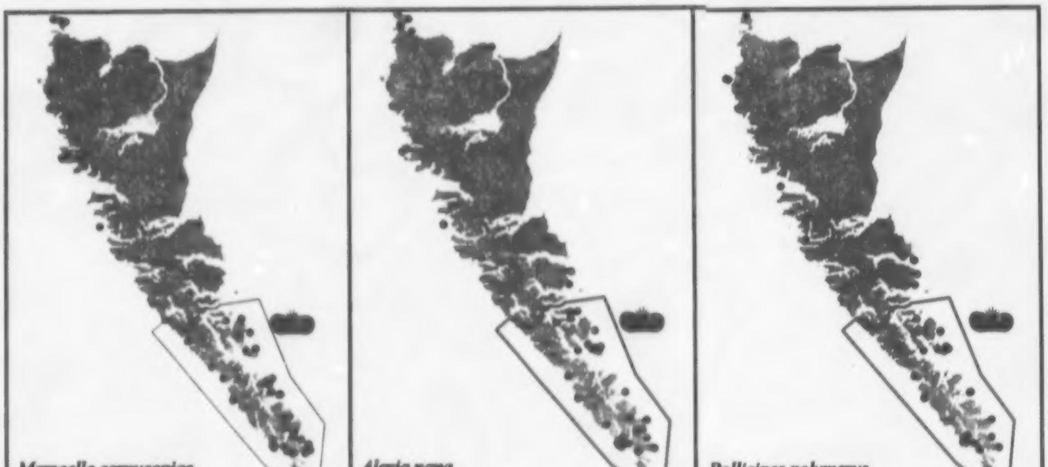

Mazzaella cornucopiae
Alaria nana
Pollicipes polymerus

Figure 18. Distributions of the goose barnacle (*Pollicipes polymerus*) and two algae species particularly characteristic of rocky intertidal shores that are highly exposed to wave action around Haida Gwaii (plant data from Sloan and Bartier 2000).

Table 12. Intertidal invertebrates used with exposure, substrate and tidal zone, to discriminate community types from aerial photographs (from Harper *et al.* 1994). Sand and sand/gravel in exposure classes VE through SE are excluded as they had no visible biota.

Tidal Zone	**Bedrock/Boulder**			**Bedrock/Boulder and Sand/Gravel**		**Estuary Sand/Mud**
	Very Exposed (VE)	**Exposed (E)**	**Semi-exposed (SE)**	**Semi-protected (SP)**	**Protected (P)**	**(SP) and (P)**
Upper	[*Balanus glandula*][1]	*Balanus glandula*	*Balanus glandula*	*Balanus glandula*	*Balanus glandula*	-
Middle	***Policipes polymerus*** [2] *Mytilus californianus* [*Semibalanus carriosus*]	***Policipes polymerus*** *Mytilus californianus* *Semibalanus carriosus*	*Mytilus californianus* *Semibalanus carriosus*	*Mytilus trossulus* *Semibalanus carriosus*	*Mytilus trossulus.*	*Mytilus trossulus*
Mid/Low	-[3]	*Anthopleura elegantissima*	*Metridium senile* *Anthopleura elegantissima*	*Metridium senile* *Anthopleura elegantissima*	*Metridium senile*	-
Lower	-	-	-	-	-	-
Subtidal	-	-	***Strongylocentrotus franciscanus***	***Strongylocentrotus franciscanus***	-	-

1 brackets [ ] around species in VE indicate presence in reduced form and abundance

2 bolding indicates diagnostic species used to distinguish between communities

3 - means no invertebrate used

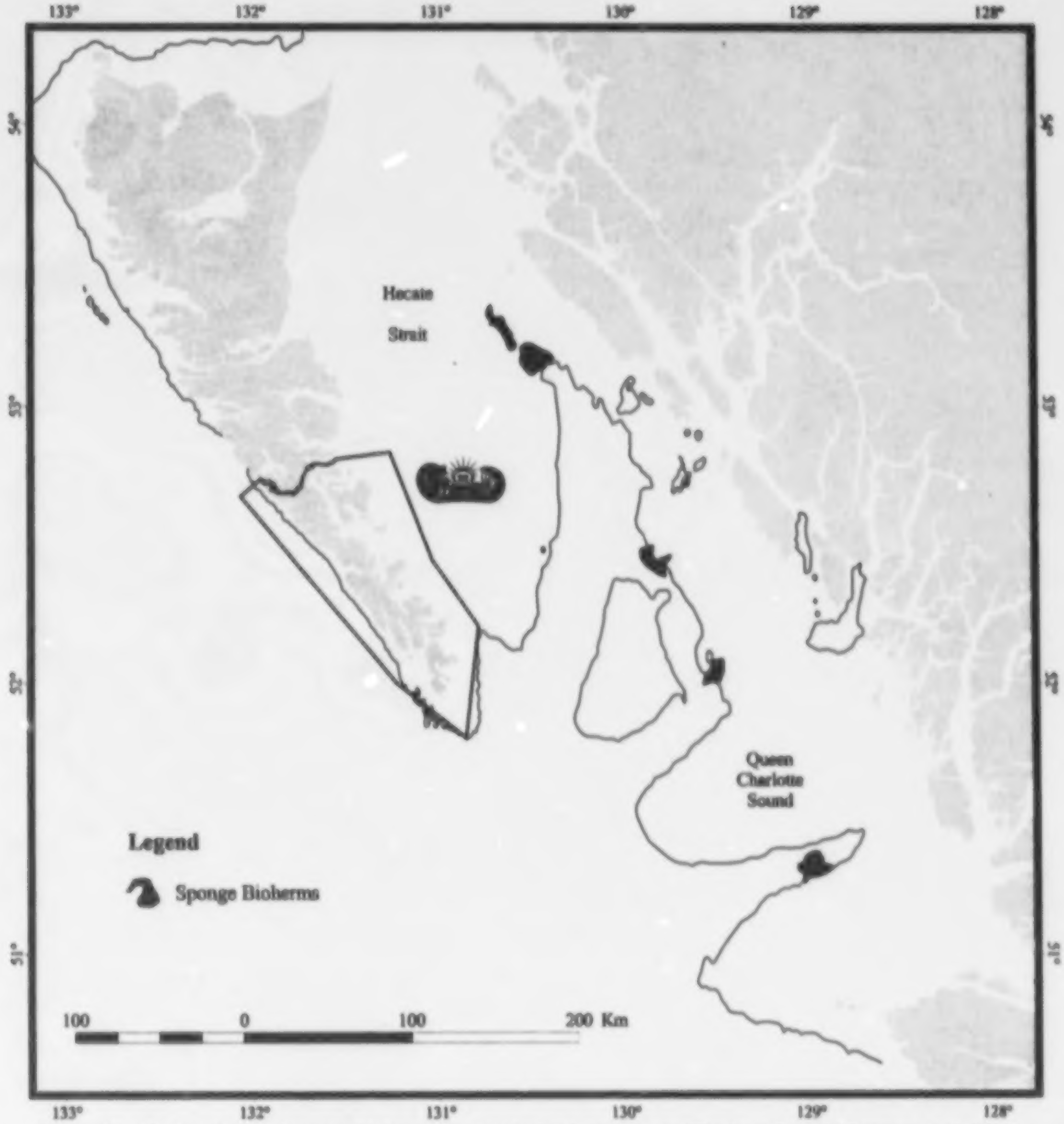
Hecate Strait. This is very different from the east coast of Vancouver Island which is sheltered from open ocean wave action. The sheltered shores of Haida Gwaii are less estuarine than the large continental inlets and river drainages of the northern British Columbia mainland coast. Despite the rainy climate of Haida Gwaii, nearshore waters are likely rapidly mixed. Haida Gwaii, therefore, has less persistent estuarine conditions than the northern mainland coast. Zacharias and Roff (2001 a) generalised that *"outer coast"* environments have more intertidal species per unit area than more sheltered waters such as the Strait of Georgia. They stated that Haida Gwaii, being *outer coast*, had the greatest intertidal species richness of the large British Columbia coastal segments they examined. Higher species diversity also occurs in many of the sheltered waters of Haida Gwaii and may reflect the high salinity conditions favoring species intolerant of fresh water dilution.

Hecate Strait and Queen Charlotte Sound Sponge Bioherms

"Globally unique sponge reefs dominated by species of hexactinellid sponges occur in the deep shelf troughs of the western Canadian continental shelf." (Conway 1999)

Illustrated in Figure 19 are the locations of the four main sponge aggregations covering ≈700 km^2 of the Hecate Strait and Queen Charlotte Sound continental shelf. These structures, discovered by the Canadian Geological Survey, Natural Resources Canada (NRCan) during marine geological surveys, are called *"bioherms"* (reef mounds) and occur in depressions at ≈160 to 230 m depth (Conway *et al.* 1991). The mainly hexactinellid (silicone-rich "glass") sponges grow skeletons that provide framework for sheet or mound formations up to 18 m thick and several km wide where appreciable tidal currents occur (Conway 1999, DFO 2000 b). Such massive living hexactinellid bioherms have, to date, not been found elsewhere. Relatively thin glass sponge mats occur in one locality in the Strait of Georgia and in several areas in the Antarctic. The bioherms are of special interest to European palaeontologists because of comparisons with the massive fossil (Upper Jurassic) sponge reef formations stretching from Portugal to Romania comprising the largest biogenic (made by living organism) structure on Earth. Hexactinellid sponge populations, usually confined to deep waters are, however, encountered on rock walls of many British Columbia fjords as shallow as 10 m (W.C. Austin, *personal observation*) and to 400 m depth in mainland fjords such as Jervis Inlet (Levings *et al.* 1983).

The three main sponge species that form bioherms promote accretion of fine silt by active removal of sediments from their outer surfaces with subsequent deposition on the substrate. Further, the vertical structure of the sponges may also serve as baffles, increasing sedimentation rates. The living sponges grow attached to the dead (sediment-interred) sponge framework; similar to the coral reef formation process of living framework on dead (Conway 1999). Healthy sponge growth must exceed the rate of sedimentation or death by smothering will occur. However, the sediments protect buried sponge skeletal elements from dissolving, thus promoting framework formation. The living surface layer is speculated to be ≈100-150 years old. Whole bioherm complexes have been growing throughout the Holocene (postglacial) epoch; from ≈8,500 to 9,000 BP. Summer 1999 submarine and geophysical surveys revealed bottom trawl damage not present during the first surveys in 1988 (Conway 1999; Conway *et al.* 2001; Krautter *et al.* 2001).


133°
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Hecate
Strait
Queen
Charlotte
Sound
Legend
Sponge Bioherms
100
0
100
200 Km

Figure 19. The locations of sponge bioherms in Hecate Strait and Queen Charlotte Sound (Conway et al. 1991; and courtesy of K. Conway, Geological Survey of Canada). The 200 m isobath showing the edge of the continental shelf is provided.

Although seaward of the Gwaii Haanas boundary, these unique marine biodiversity assets are a regional conservation issue given the representation intent of Gwaii Haanas for the Hecate Strait marine natural region (Mercier and Mondor 1995). The bioherms have been recommended as an area-specific candidate for DFO to begin consultations towards a site-specific marine protected area (MPA) as mandated under the *Oceans Act* (Stocker and Pringle 2000). Key management issues, according to

Conway (1999 and DFO (2000 b), are as follows:

- bottom trawling is a direct threat to the bioherms for which physical damage may take 100 to 200 years to heal; and
- the bioherms could act as finfish and shellfish (invertebrate) nursery areas contributing to the Hecate Strait ecosystem including commercial stocks.

We superimposed the sponge bioherm locations over Ecosection and Ecounit boundaries within Hecate Strait as the bioherms' presence manifests similar habitat types (Figure 20). The bioherms fitted into the Queen Charlotte Sound Ecosection. Further, the bioherms are reasonably well characterized within Ecounit types, given that Ecounit boundaries are likely somewhat fuzzy anyway. The bioherms are characterized by occurring below areas exposed to high winds and waves, over substrates of low relief, in currents <3 knots and on fine sediments. However, these are not sufficient conditions for formations of the bioherms as they occupy only small areas within Ecounits. We suggest that other conditions such as upwelling characteristics, silicate levels in seawater and suspended and deposited sediment load may also be important. For example, the silicate levels in coastal British Columbia waters are higher than anywhere else in the world except the Antarctic and the Bering Sea (Austin 1984, 1999 b).

Marine Invertebrates Introduced to Haida Gwaii

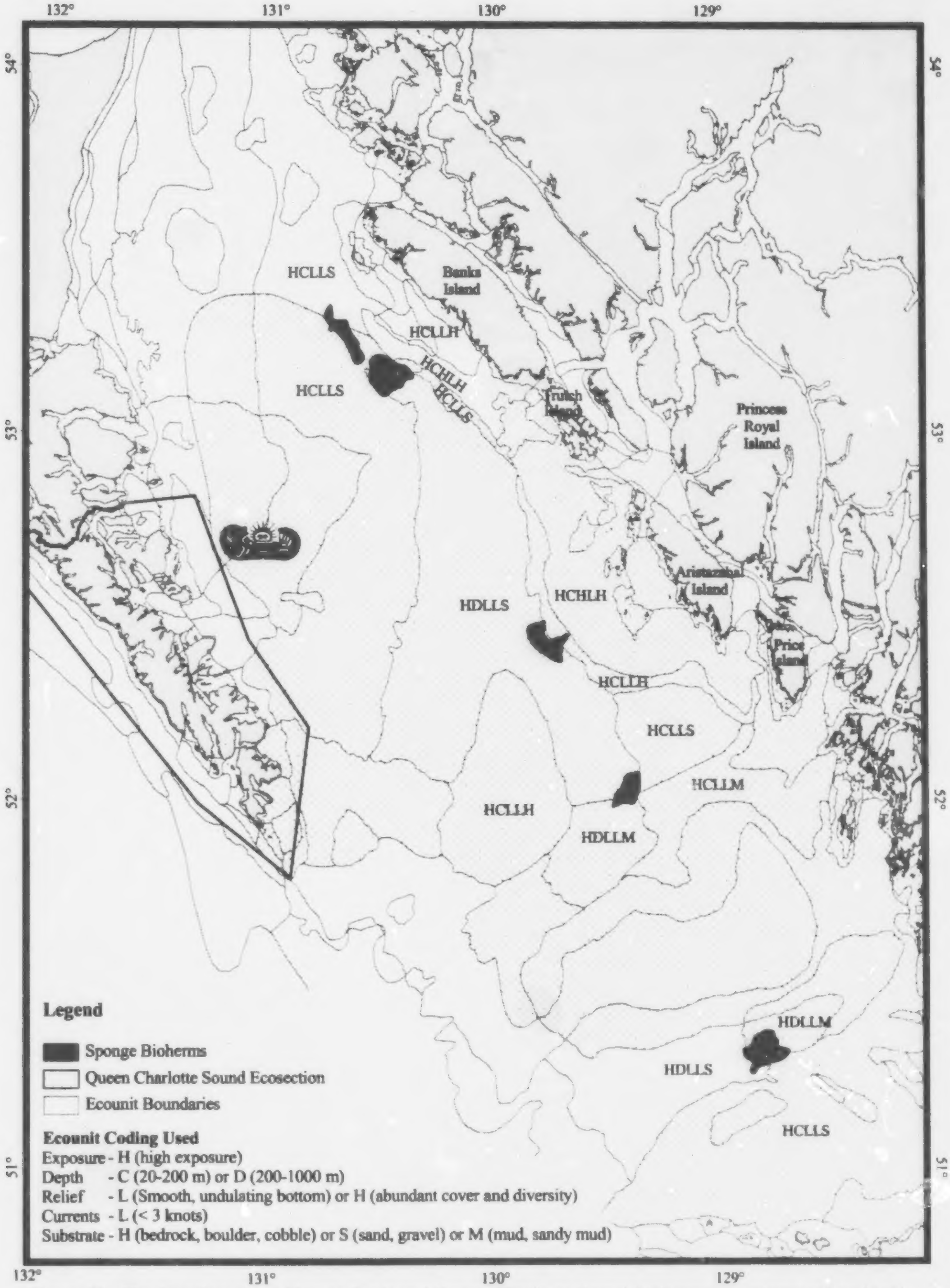
"The debate about the precise amount of fishing to allow in a marine reserve can easily be rendered moot by an invader." (Simberloff 2000)

"... the control of alien marine species is in its infancy." (Bax *et al.* 2001)

Simberloff's (2000) concern is based largely on invading marine algae which threaten conservation areas in the Caribbean and Mediterranean. However, non-indigenous marine invertebrates are a concern as well. The dynamism and connectivity of marine ecosystems means that there is a constant threat of foreign species introduction by dispersal of their propagules (larvae or spores) in currents. This topic has received less attention in marine conservation area design and management and the field is much more developed in land and freshwater conservation than in marine conservation (Simberloff 2000; Bax *et al.* 2001). There are ≈30 species of introduced mollusks alone now on the Pacific coast of North America (Carlton 1992) with the main modes of introduction being:

- ≈27 species associated with introduced (for culture) Japanese and Atlantic oysters;
- ship hull fouling and wood boring; and
- overseas ships' ballast water releases.

For Haida Gwaii, accidental introductions, active introductions for fishery enhancement and economic development, and feasibility studies for large-scale introductions, are summarized in Table 13. Foreign (exotic) marine invertebrate species have come to Haida Gwaii, usually northward from the southern mainland British Columbia and U.S. coasts where they first became established. There have been introductions of species to British Columbia targeted for aquaculture development, such as oysters (*Crassostrea gigas*) from Japan, plus their attached associates (Quayle 1988) or parasites (Bower *et al.* 1994). For example, the seaweed *Sargassum muticum* is now ubiquitous coast-wide, including Haida Gwaii (Sloan and Bartier 2000). It was first introduced into southern British Columbia in the 1930s attached to Japanese oysters. Another possible example is the parasitic copepod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HCLLS
Banks Island
HCLLH
HCHLH
HCLLS
HCLLS
Trutch Island
Princess Royal Island
HDLLS
HCHLH
Aristazabal Island
Price Island
HCLLH
HCLLS
HCLLM
HCLLH
HDLLM
HDLLM
HDLLS
HCLLS
Legend
Sponge Bioherms
Queen Charlotte Sound Ecosection
Ecounit Boundaries
Ecounit Coding Used
Exposure - H (high exposure)
Depth - C (20-200 m) or D (200-1000 m)
Relief - L (Smooth, undulating bottom) or H (abundant cover and diversity)
Currents - L (< 3 knots)
Substrate - H (bedrock, boulder, cobble) or S (sand, gravel) or M (mud, sandy mud)

Figure 20. The location of the Hecate Strait and Queen Charlotte Sound bioherms superimposed on local Ecosection and Ecounit boundaries. The Ecosections around the bioherms are identified by their 5-letter codes depicting, in sequence, exposure/depth/ relief/currents/substrate. Note that all start with H for high exposure.

Table 13. Marine invertebrate species either introduced to Haida Gwaii or those whose introduction was discussed, attempted or done for mariculture.

Species	Notes	References
Hydrozoan *Tubularia crocea*	Observed (collected?) in 2 locations in Houston Stewart Channel, in 1935	Fraser (1936b)
Soft-shell Clam *Mya arenaria*	Introduced in ~early1900s, now found coast-wide	Carl and Guiguet (1958)
Japanese Oyster[1] *Crassostrea gigas*	Introduced into the south coast of British Columbia in the early 1900s where it has established in the wild - juveniles[1] taken to two pilot raft culture sites (see below) and one commercial lease site in Skidegate Inlet	Haida Gwaii Marine Resources Group Association, Masset
Weathervane X Japanese Scallop hybrid (*Patinopecten caurinus* X *Patinopecten yessoensis*)	Juveniles[2] imported in 1997 to 4 pilot raft culture sites mostly in the Masset Inlet, off Masset, Skidegate Inlet and Rennell Sound – the first and last sites also had some Japanese oysters	Haida Gwaii Marine Resources Group Association, Masset
Manila Clam *Venerupis philippinarum*	DFO introduced 15,000 each into Masset Inlet and Naden Harbour in 1962 – none were located in a 1997 survey	Gillespie and Bourne (1998)
Snail *Sabia conica*[4]	Widespread in the western Pacific, collected in Tasu Sound, 1963	Kozloff (1996)
Atlantic Lobster *Homarus americanus*	DFO feasibility studies found the Hecate Strait area south of Skidegate Inlet (3,100 to 7,770 km^2) suitable for introduction, along with Masset Inlet – but none were introduced	Ghelardi and Shoop (1972), Barber (1983)
Gribble (isopod) *Limnoria lignorum*	A wood-boring crustacean now found coast-wide	Carl and Guiguet (1958), Quayle (1992)
Amphipod *Ampithoe vallida*	Collected from 4 locations in 1957.	CMN[3]
Amphipod *Erichthonius brasiliensis*	Collected in 1935 from the south shore Houston Stewart Channel by C. McLean Fraser	CMN[3]
Amphipod *Neohela monstrosa*	Collected in 1991 from 425m depth off Langara Island by the RBCM/CMN "Deepwater II Expedition"	CMN[3]
Caprellid Amphipod *Caprella penantis*	Collected in 1957 near a creek mouth at the south side of Gudal Bay, Cartwright Sound by E.L. Bousfield	CMN[3]
Carabid Intertidal Beetle *Trechus obtusus*	Introduced from Europe	Kavanaugh (1992)
Bryozoan *Cryptosula pallasiana*	Collected in 1968 from three nearshore sites around Langara Island by N.A. Powell	CMN[3]
Bryozoan *Schizoporella unicornis*	Observed in 1992 in the SGaang Gwaii intertidal by W.C. Austin	Harper *et al.* (1994)
Tunicate *Ciona intestinalis*	Collected in 1976 from 18m depth at end of Fairfax Inlet, Tasu Sound by P. Lambert	RBCM[4]
Tunicate *Pelonaia corrugata*	Observed in 1906 off Rose Spit - introduced from Japan	Huntsman (1912), Kozloff (1996)

1 Japanese oysters will not breed in the colder waters of Haida Gwaii, but introduced juveniles ("spat") grow well; juveniles are certified disease-free by the commercial supplier

2 Juvenile scallops ("spat") are certified disease-free by the commercial supplier

3 specimens in the Canadian Museum of Nature (CMN)

4 specimens in the Royal British Columbia Museum (RBCM)

Mytilicola orientalis, likely introduced in culture oyster stock from Japan and now widely infesting native bivalves such as littleneck clam (*Protothaca staminea*) and butter clam (*Saxidomus giganteus*) (Bower *et al.* 1994). Table 13 includes only species that were explicitly recorded from Haida Gwaii. We did not include introduced species that have been recorded nearby but outside the Haida Gwaii region. An example is the amphipod *Corophium acherusicum* from Asia and now known from the northern mainland British Columbia coast (Carlton 1979; Bousfield and Hoover 1997).

In 1977, concern over introduced aquatic species issues stimulated establishment of the federal/provincial Fish Transplant Committee under mandates from the federal *Fisheries Act* and the *British Columbia Wildlife Act* and *British Columbia Fisheries Act* (BC 1990). The Committee evaluates potential commercial benefits and risks to the environment associated with both finfish and invertebrate (shellfish) introductions by any proponent into British Columbia marine and freshwaters. The risks warranting mitigation are uncontrollable spread of the introduced species, their attached associates, their diseases, their parasites and genetic material into native species. The Transplant Committee issues licenses to transplant into British Columbia and between areas within British Columbia. Haida Gwaii is "Zone 6" within the nine coastal and inland zones of British Columbia. For invertebrates, the Committee's activities are linked with other entities as described in the section on public health and safety of seafood provided later.

Another avenue of introduction is from shipping ballast water. Canada receives ≈52 million tonnes of ballast water from foreign shipping annually with no specific ballast water regulations, no national policies and no national action plan (Gauthier and Steel 1998). In discussing Pacific Canada, Levings (1999) mentioned proposed national guidelines for ballast water management. Further, the Vancouver Port Authority has had its own mandatory ballast water program since 1997. It is based on the assumption that mid-ocean ballast water exchange, with water containing pelagic species not likely adapted to coastal conditions, is optimal for in-coming vessels from foreign ports. No other British Columbia ports outside of Vancouver invoke ballast water management. Therefore, the north coast of British Columbia, with an active deep-water, international port in Prince Rupert, is currently unprotected against species introductions from foreign ships' ballast water.

Shellfish mariculture is another potential avenue of species introduction to Haida Gwaii. There is a commercial lease in Skidegate Inlet for Japanese oyster (*C. gigas*) culture. This is not likely a threat as these waters are too cold for oyster breeding although productive for growth of the certified disease-free juveniles. In 1997, the Masset Shellfish Committee established four pilot raft culture sites for certified disease-free scallop hybrids (B. Mark, Masset, *personal communication*; Table 13). The grow-out experiment is still running at some sites. The potential for species introduction seems low, because no successful settlement of hybrid weathervane scallops has occurred in the wild in British Columbia in last decade (Island Scallops Ltd., Qualicum Beach, *personal communication*).

As late as the 1980s, introduction of a large, predatory species such as Atlantic lobster (*Homarus americanus*) was being discussed in DFO publications on broad-scale fishery development in Haida Gwaii (Table 13). Now, such initiatives are contrary to agency thinking and mandates for ecosystem-based management and maintenance of local ecological integrity.

Generally, the ecological effects of introduced invertebrates on the Pacific coast are poorly studied (Carlton 1992). It is sobering to reflect that, once introduced, foreign marine species are difficult to control and their ecosystem consequences potentially great. An example is the invasion by the intertidal European green crab *Carcinus maenas* introduced to the San Francisco Bay area in 1989. The species has already reached Nootka Sound on the northern west coast of Vancouver Island (G. Jamieson, DFO, *personal communication*) and could get to Haida Gwaii. As an active predator, the green crab is expected to have an appreciable impact on native intertidal fauna, as it has in California (Grosholz 2000). The concern has led DFO to maintain a green crab site: http://www.pac.dfo-mpo.gc.ca/ops/fm/crab/

Marine Habitat – Invertebrate Relations in Haida Gwaii

"And yet we still know more about the topography of Venus (99% of which has been mapped in enough detail to reveal features on the order of 50 m in height) than we know of our own ocean floor (less that 10% has been charted at a similar resolution)." (Wright and Goodchild 1997)

This section provides brief generalizations for the Haida Gwaii region according to estuarine, nearshore, continental shelf and offshore (benthic and pelagic) habitats. Special mention is made of the coastal land-sea transition area.

Gwaii Haanas is very rich in sea/land interface with ≈1,700 km of marine shoreline. This interface is a dominant feature of Gwaii Haanas. The irony is that this intertidal shoreline band, where most visitation takes place, most of the archaeological sites are found and key habitats such as estuaries occur, is the least well covered in our GIS as it falls between terrestrial and marine measuring conventions. This can impede applications of spatial computer tools for supporting biodiversity knowledge along (and across) this coastal transitional band. This must be resolved for sound long-term, ecosystem-based management.

An example of different conventions is the projection used for positioning at sea is latitude and longitude, whereas that for positioning on land uses Universal Transverse Mercator (UTM). The first major problem originates from differing surface measuring technologies for land and sea. Base map elevation data are topographic for the land and bathymetric for the sea. Land base map data are derived from aerial photographs using photogrammetric technology. These maps are available from provincial (British Columbia Ministry of Sustainable Resource Management) Terrain Resources Information Maps (TRIM) or federal (NRCan) National Topographic Series (NTS) sources. Marine base map data are derived from hydrographic soundings made by the Canadian Hydrographic Service (DFO). The land and sea technologies serve their respective user groups well. However, when the two base map sources are combined, there is an appreciable data gap in the intertidal and adjacent shallow subtidal. An example of actual data is shown in Figure 21 of Werner Bay, Juan Perez Sound. In this area, current multi-beam sonar (swath bathymetry) and side scan sonar technologies were used (Mandryk *et al.* 2001), the data points are so dense that they almost form a continuum. As the seawater shallows, this data coverage becomes ragged where the technology was difficult to apply. Moreover, the intertidal data are very spotty, being based on irregular data points likely from the original charting done from 1941 to 1958. On the land, the

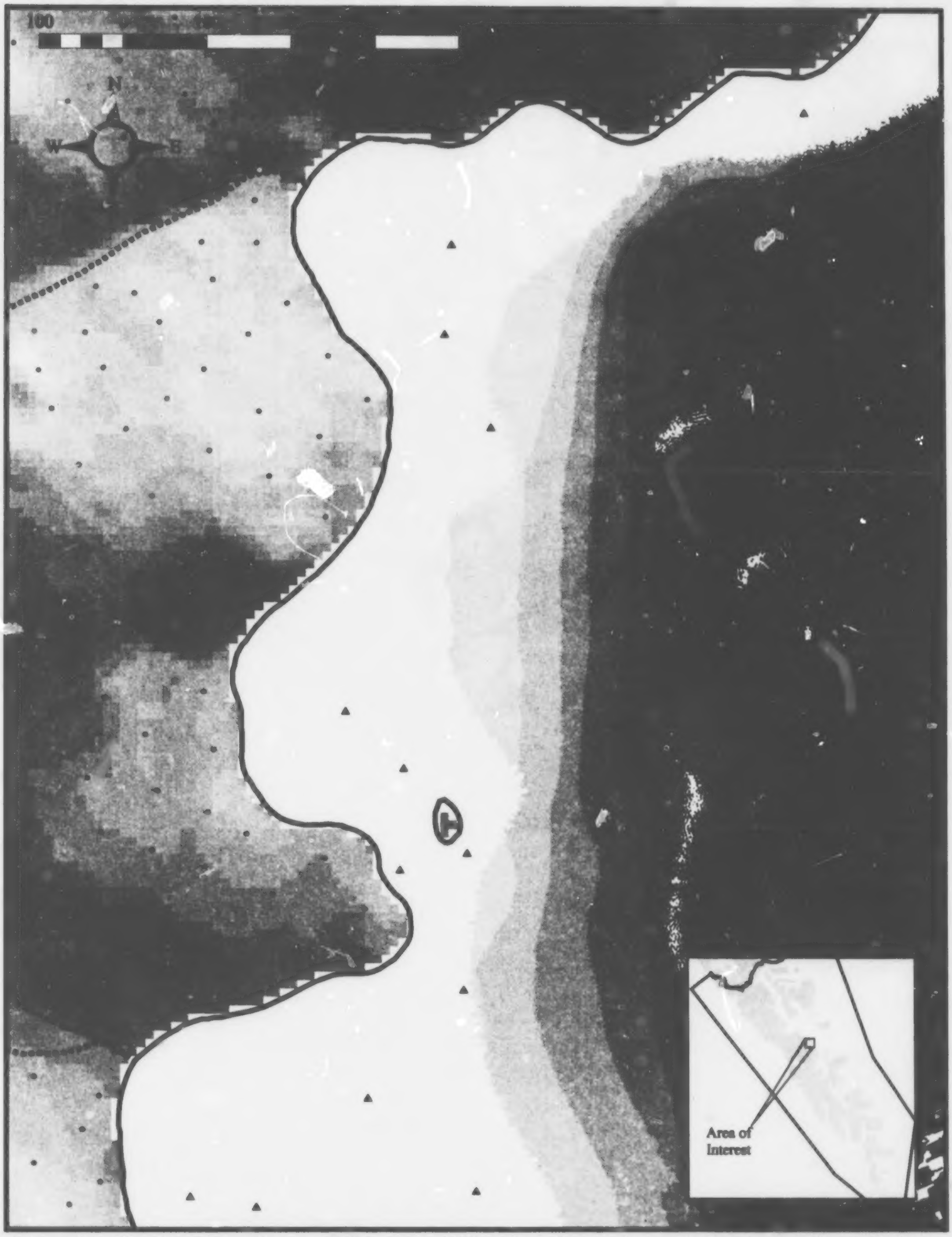

Figure 21. Combinations of terrestrial (topographic) and marine (bathymetric) basic elevation data from Werner Bay, Juan Perez Sound showing the poor data coverage in the intertidal and shallow subtidal. White smudges in the sea areas of thin depth data coverage.

photogrammetric analyses yielded fairly regular coverage at approximately one point every 75 m. Generally, on land there are fewer points on flatter terrain and more on variable terrain.

The second major problem relates to the different vertical datums for terrestrial elevation and marine bathymetry. This can introduce error when attempting to join land and sea base maps. Terrestrial topographic maps express elevation relative to "*mean sea level*", as established by the Geodetic Survey of Canada (NRCan). Mean sea level is the theoretical (equipotential) surface of Earth's oceans in the absence of all forces *except* gravity. An equipotential (level) surface experiences gravity everywhere perpendicularly. Marine charts express depths relative to "*chart datum (lowest normal tide)*" defined by the Canadian Hydrographic Service as "*... the lowest tide that can be expected in a given locality considering gravitational effects alone.*" This excludes the effects of weather (winds and storm surges) that can further lower seawater levels. Basically, therefore, chart datum is lowest low tide level. The relationship between these standards turns out to be a moving target that varies geographically in a complex manner. This creates uncertainty unless this complex relationship is assessed on a site-by-site basis.

Estuaries

Estuaries are strategically situated between the land and sea. They are semi-enclosed coastal water bodies where freshwater runoff from the land measurably dilutes the seawater. Estuaries are productive habitats that contain a specialized biota.

Ray *et al.* (1997) proposed a "*landscape-pattern*" approach towards understanding the ecological function of nearshore biodiversity. They used estuarine benthic invertebrate assemblages, besides fish assemblages, to reflect boundary conditions of biogeographical entities. Further, they discussed how species' life histories "*provide the functional linkages among differing scales of ecological interaction.*" For ecosystem-based management in estuaries Ray *et al.* (1997) recommended the following:

- descriptions of species' life histories in terms of their environmental relationships;
- determination of controls on boundary conditions, and;
- quantitative, landscape-level descriptions of estuarine habitats.

Although estuaries represent only ≈6% of Gwaii Haanas' ≈1,700 km of coastline (Harper *et al.* 1994), they are important as land-sea linkage points. Estuaries are where salmonid species pass through to spawn and rear in as juveniles before their marine life phase and where migratory birds temporarily rest and feed. Spawning salmonids are particularly important to the transfer of ocean nutrients into the near-coastal lands of small watersheds that characterize Gwaii Haanas (Reimchen 1994, 2000). In Gwaii Haanas' coastal biophysical inventory, Harper *et al.* (1994) recommended a separate inventory of estuaries and attendant saltmarsh vegetation habitat types. This inventory is now underway.

The transition region from land, through estuaries to the sea presents both opportunities and challenges. The opportunity for Gwaii Haanas is that it can deliver mountain-top to sea shore protection on virtually all its watersheds. Many of these watersheds were never logged, some were logged earlier in the 20th century and all logging stopped by 1986. These relatively undisturbed uplands, therefore, could make the Gwaii Haanas watersheds reference sites for land-sea linkage research and monitoring.

Nearshore (Intertidal and Shallow Subtidal)

We are in a good position to make generalizations about the occurrence of dominant rocky intertidal invertebrates according to substrate (type and grade) and exposure to wave action in Haida Gwaii. These physical factors of substrate and exposure underpin broad-scale generalizations on the structure of rocky intertidal communities in British Columbia (Zacharias *et al.* 1999; Zacharias and Roff 2001 a). The Harper *et al.* (1994) coastal biophysical survey of Gwaii Haanas (done in 1992) provides data to aid in predictions of community types. Updating this survey began in 2001 to bring it up fully to contemporary standards. When completed, this will put the entire British Columbia coast (including northern Haida Gwaii) at a common standard on the GIS of the British Columbia Land Use Coordination Office (LUCO) [renamed in 2001; Resource Planning Division, Ministry of Sustainable Resource Management], Victoria [http://www.luco.bc.ca]. The presence of many visible, dominant rocky shore species can be inferred, therefore, from wave exposure criteria for the whole archipelago. However, other factors such as nutrients, salinity, upwelling, sand-scour, tidal currents, tidal amplitude may also have effects on rocky shore species composition. Similarly, wave exposure, as reflected in part by sediment composition, but also nutrient input (e.g., estuaries and upwelling), salinity, tidal currents and other factors may affect infaunal (burrowing) invertebrate species composition. Infaunal communities have been less well surveyed in Gwaii Haanas.

We are not in a position to make meaningful generalizations on the occurrence of shallow subtidal invertebrates according to Haida Gwaii habitat. There are the ubiquitous red sea urchin barrens wherever suitable rocky bottoms occur, but the ecology of these regional barrens is little investigated in Haida Gwaii (Jamieson and Campbell 1995). With the exceptions of Burnaby Narrows and Murchison-Faraday Pass (TEC/HFP1993, 1994), rocky subtidal areas such as reef and kelp forest areas are not well sampled. Bottom topography and sediments are well recorded for a few areas such as Juan Perez Sound and Houston Stewart Channel, which have been partially sampled through grab surveys by the Geological Survey of Canada. The shallow subtidal sediment infauna remains little investigated elsewhere in Haida Gwaii. We know from southern British Columbia areas that polychaete and clam species groups are conspicuous components of sediment ecosystems and have been used to differentiate sediment faunas from different areas (Ellis 1969). Perhaps similar groupings could be used in this region.

Continental Shelf including Hecate Strait and Queen Charlotte Sound

On the eastern side of Gwaii Haanas the continental shelf comprising Hecate Strait and Queen Charlotte Sound is the most studied regional shelf area (e.g., Burd and Brinkhurst 1987 on infauna and Conway *et al.* 2001 on the sponge bioherms). Beginning in 1982 and still on-going, DFO initiated the Hecate Strait Survey aimed at understanding the bottom-trawled finfish populations (Tyler 1986). This is the first Haida Gwaii regional multispecies marine research initiative by DFO. Its goal is to understand relationships among selected (commercial) species to enable a multispecies management approach in the Strait. In essence it is the rudimentary beginning of regional continental shelf ecosystem research. Invertebrates feature in fishes' gut contents data currently being worked up, but are not part of the regular sampling. Work on the project has continued with new three-year funding starting in 2001 (J. Fargo, DFO, *personal communication*)

The continental shelf off the west coast of Haida Gwaii is sediment-poor and relatively rocky (Barrie and Conway 1996). Depth, bottom relief and substrates are unknown where this area (the last region of Pacific Canada) remains uncharted. The uncharted coast extends approximately from Nagas Point north to Englefield Bay with Gowgaia Bay and Tasu Sound being the only charted inlets along that coastline. The sediment infauna on the open shelf areas is virtually uninvestigated and that of its inlets has fared little better, with the exception of Tasu Sound (Brothers 1978) before the mine, with its submarine tailings disposal, ceased operations in 1983.

With rocky ground in exposed shelf areas of such dynamic water mixing, perhaps there are deep-water groves of attached suspension-feeding corals or sea fans. For example, the tree coral *Primnoa willeyi* was seen during a submarine dive nearby a sponge bioherm in 1999 by W.C. Austin. Concern for the well-being of these colonial invertebrates has increased in recent years (Risk *et al.* 1998). Long-liners do snag and retrieve large coral colonies which are used in the Haida Gwaii craft industry (L. Doerksen and F. Watmough, Queen Charlotte City, *personal communications*). Off Nova Scotia, fishers' experiential knowledge has been important to inventory regional deep-water coral populations (Breeze *et al.* 1997). The same type of survey badly needs to be done for both continental shelf and slope areas of Pacific Canada. In mainland coastal fjords, however, there are data on coral tree distribution (W.C. Austin, *unpublished observation*). There is some urgency as Probert (1999) speculated that damage from fishing gear, such as bottom trawl, may be greater in the deep-sea given the generally slow growth rates of corals and sea fans in these cold water habitats. This would mean that recovery times for these ecosystems after damage could likely be relatively long.

Continental Slope and Offshore Benthic (deep-sea systems)

The greatest information gap on invertebrates of the Haida Gwaii region is from the deep ocean. Few have sampled the deep-sea sediments for burrowing infauna or the sea bottom surface for its epifauna. The major recent exception is the DFO trawl-swept survey of summer, 2000 mentioned in the fishing section below. With the exception of Gowgaia Bay, the west side of Gwaii Haanas north of Nagas Point is incompletely surveyed and roughly charted, so we have a poor information base (depth / bottom topography / sediments) even to start understanding invertebrate-habitat relationships.

Offshore Pelagic (open ocean systems)

"...water masses provide a proxy for biogeographical distributions of typical assemblages of pelagic species, but rarely for any individual taxa." (Angel 1997)

There are few non-planktonic, true pelagic (ocean water column) invertebrate species. These are the nekton, or species that swim actively in the sea's three dimensions rather than drifting with the water currents. Plankton, on the other hand, are either totally passive or move slowly through the water. Such slow movement, however, may result in significant migrations up and down in the water column such as by euphausiids and large copepods. Typical nektonic invertebrate groups of this region are squid such as the neon flying squid (*Ommastrephes bartrami*) (Sloan 1991).

Virtually nothing is known about this region's nektonic invertebrates. The ecological roles of squids around Haida

Gwaii are unknown, although the group is doubtless important to local pelagic ecosystems. The populations are there because sperm whales (*Physeter macrocephalus*), specialist predators on deep-water squids, are active along the continental shelf edge off the west coast of Haida Gwaii (Nichol and Heise 1992).

MARINE INVERTEBRATE FISHERIES (SHELLFISHERIES) OF THE HAIDA GWAII REGION

"The truth is that we need invertebrates but they don't need us." (E.O. Wilson 1987)

"The fishing of a variety of marine species is going to remain an economic and socio-political reality, so we need to know how to ensure that it is done in an ecologically-sound fashion." (Dethier *et al.* 1989)

NEW DIRECTIONS FOR FISHERIES WITHIN MARINE AREA MANAGEMENT

Preparations for public consultation prior to declaring Gwaii Haanas as a National Marine Conservation Area coincide with significant changes to how Canada will manage human effects on marine ecosystems. Within Haida Gwaii, Gwaii Haanas fisheries management will likely differ compared to that for the rest of the archipelago. Parks Canada Agency marine policy supports sustainable fishing provided that ecosystem structure and function are not impaired (Parks Canada 1994). There is, therefore, both opportunity and uncertainty as we enter a new era in Canadian protected marine area management.

Some important caveats must be stated. Firstly, when we use the word *manage*, we mean managing human effects on species and ecosystems – species and ecosystems themselves are not manageable by people. Secondly, Jackson *et al.*'s (2001) generalization that, globally, overfishing is the greatest human threat to coastal ecosystems may not be applicable specifically for Gwaii Haanas' intertidal to very shallow subtidal areas. An exception could be the diving (slightly deeper subtidal) fishery for northern abalone. The irony is that human impacts in the intertidal and very shallow subtidal are likely less now than in the past. For example, many more Aboriginal people were living permanently, and gathering invertebrates, in the Gwaii Haanas area for millennia before the 1860s than now (Acheson 1998).

Overfishing, however, is a reality along the British Columbia coast as a whole and remains a significant marine conservation issue. Historical examples are stock collapses of pilchard (*Sardinops sagax*) in the mid 1940s, Pacific herring (*Clupea harengus pallasi*) in the mid 1960s and northern abalone in the 1980s. Moreover, there are serious current problems for some stocks in some areas such as rockfishes (*Sebastes* spp.) in the Strait of Georgia and for salmonids (*Oncorhynchus* spp.) from certain river systems. Further, Pauly *et al.* (2001) reviewed British Columbia fisheries data from 1873 to 1997 and concluded that, overall *"... west coast fisheries are also unsustainable at the ecosystem level"* after assessing the decline in average trophic level of fisheries species landed.

Management of Gwaii Haanas will likely be by a partnership between Parks Canada Agency and Fisheries and Oceans Canada (DFO) on the federal government side of a management agreement with First Nations (the Haida Nation). Other stakeholders such as, for example, the commercial fishery sector, coastal communities, environmental non-government organizations (NGOs) and tourism/recreation industries must also be involved. This will build upon the success of the 1993 nation-to-nation *Gwaii Haanas Agreement* overseeing terrestrial management of Gwaii Haanas (Hawkes 1996).

A maritime arrangement would likely devolve some level of fisheries assessment, research and management decision-making to the Gwaii Haanas management partnership. Therefore, the DFO mandates from the *Fisheries Act* and the *Oceans Act* and the Parks Canada Agency mandates from the *Canada National Parks Act* (2000) and the proposed *Canada National Marine Conservation Areas Act* would be executed cooperatively within a fisheries management framework for Gwaii Haanas.

The marine protected areas components of the *Oceans Act* and the proposed *Canada National Marine Conservation Areas Act* have complimentary flexibilities in the ranges of activities permitted, after the public consultation process, on a site-by-site basis. Both potentially permit Aboriginal, commercial and recreational fishing, marine aquaculture (mariculture), research, education, tourism/recreation, ocean dumping and shipping activities. Only the *Canada National Marine Conservation Areas Act*, however, explicitly prohibits non-renewable resource (aggregates, minerals, petroleum) extraction by legislation. In contrast, the *Oceans Act* relies entirely on the potential for regulation, that is, on the DFO Minister's discretion to specify "*the prohibition of classes of activities*" within a specific marine protected area rather than on broad legislated prohibitions. It is noteworthy that in the *Canada National Marine Conservation Areas Act* text, a fishing licence issued under the *Fisheries Act* is deemed to be a permit under the proposed legislation. In other words, the primacy of the *Fisheries Act* in fisheries management issues within a national marine conservation area is observed in the proposed *Canada National Marine Conservation Areas Act*.

The field of mariculture impacts on coastal biodiversity is just emerging (Beveridge *et al.* 1997). This issue, although highly topical in British Columbia (e.g., Bourne 1997; Bendell-Young and Ydenberg 2001), is not discussed here because the remoteness of Haida Gwaii, and Gwaii Haanas in particular, currently renders the economic prospects of mariculture marginal. Mariculture is not prohibited in the proposed *Canada National Marine Conservation Areas Act*. Further, future economic conditions could, of course, change, but there is enough to deal with the fisheries issues for now!

The prospect of a Gwaii Haanas marine area comes at a time of increased commitment to public consultation in Canadian marine conservation by agencies and NGOs (Parks Canada 1994; Anonymous 1998; Burrows 2000; CPAWS 2000; Day and Roff 2000; Wallace and Boyd 2000; Symington and Jessen 2001) and by shellfisheries managers (Harbo 1998; Orensanz and Jamieson 1998). Indeed, growth in the NGO sector's involvement in marine conservation world-wide has recently been rapid. An example is the 1998 global marine policy of the World Wildlife Fund/World Conservation Union (WWF/IUCN):

http://www.panda.org/resources/publications/water/seachange/.

WHY DISCUSS MARINE INVERTEBRATE FISHING?

Fished marine invertebrates ("shellfish") are a large and dynamic topic in British Columbia with over 35 species taken, many management regulations and high economic value (Harbo 1998). The management of Haida Gwaii shellfisheries is complex and includes over 20 species with some regional fishing history. There are species with very different life histories, highly variable and evolving management regimes and differing consultative management partnerships. Exhaustive individual fisheries information is available from DFO as detailed below. Accordingly, we present an overview on the biology (life history), management, yield and potential contribution to conservation understanding of the Haida Gwaii shellfisheries for a broad readership. Also provided is guidance to the science and management source materials enabling more detailed enquiry. A shellfish web site for access to the extensive information relevant to biology and management has been developed by DFO:

http://www.pac.dfo-mpo.gc.ca/ops/fm/shellfish/index.htm

Accommodating shellfisheries in Gwaii Haanas is a pivotal issue for its eventual marine management partnership for the following reasons:

- most shellfish stocks have spatially persistent benthic (bottom-dwelling) adult populations, connected by temporary planktonic (suspended in the water column) larvae, that both provide focal points for discussions on ecosystem scale, monitoring and zoning;
- the population dynamics of commercial shellfish larvae is not well known, and the nearshore oceanography virtually unknown, for the Haida Gwaii region and these characteristics confer very different management constraints among the individual fisheries;
- shellfisheries management varies significantly among species and these differences must be understood and made explicit to assess how fishing will operate to coexist with other activities mandated within conservation area management;
- high cultural value of shellfish to the Haida Nation;
- high commercial value of shellfish from Haida Gwaii and high proportion of commercial landings of some species from the Gwaii Haanas area relative to the north coast region and coast-wide in British Columbia;
- the closed northern abalone (*Haliotis kamtschatkana*) fishery involves Canada's first commercial marine invertebrate listed by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) as "*threatened*", thus invoking species-at-risk concerns; and
- the likely future establishment of breeding populations of the sea otter (*Enhydra lutris*) to Gwaii Haanas would induce nearshore ecosystem changes (via kelp forest expansion) and perhaps negatively effect some shellfisheries.

SHELLFISH MANAGEMENT AND POLICY OVERVIEW

Evolving Mandates and Policies

Final authority for conservation of Haida Gwaii shellfisheries rests with DFO, Pacific Region as mandated under the *Fisheries Act*. The first management priority is for stock conservation. The second priority is for enabling the constitutional right of Aboriginal people (*Constitution Act*, 1982 - Section 35) to gather invertebrates for food, social and ceremonial purposes. Access is negotiated with First Nations through the Aboriginal Fisheries Strategy. This right was upheld in the Supreme Court of Canada *Sparrow* decision of 1990, which included a directive to DFO to consult First Nations before imposing any (conservation-related) restrictions to their access for food, social and ceremonial purposes. The third priority is for commercial and recreational sector requirements. Besides sustainability and optimal resource use for social and economic objectives, other DFO management objectives include consensus-building for resource management through stakeholder consultation and habitat protection, and shellfish quality control (seafood safety) in cooperation with the Canadian Food Inspection Agency and Environment Canada (EC).

A new consideration is DFO's evolving mandate, under the *Oceans Act* of 1996, towards ecosystem-based fisheries management (Sinclair *et al.* 1999). This new policy considers aggregate ocean uses, ecosystem well-being, multispecies interactions and invoking the **precautionary approach**. This approach embodies conservative (risk-averse) action in the absence of certainty, not waiting for full scientific proof prior to decision-making and thinking about the legacy to those who will follow, i.e., *"intergenerational equity"* (Lauck *et al.* 1998; Richards and Macguire 1998; Hilborn *et al.* 2001). This is such an important concept to the future of marine area conservation that Garcia's (1996) definition of the approach is provided. Garcia described the precautionary approach as a set of agreed, cost-effective measures and actions including future courses of action, which ensures prudent foresight, reduced or no risk to the resources, the environment, and the people, to the extent possible taking explicitly into account existing uncertainties (i.e., lack of full scientific certainty) and the potential consequences of being wrong. Other components of the precautionary approach are:

- that proponents for change from conservative, risk-averse action should assume the burden of proof that their proposed actions are not damaging (Dayton 1998) and, therefore, fund science to assess the implications of any such change; and
- applying the approach to the protection of people (not just stocks) through managing risks of fisheries management decisions to coastal communities (Hilborn *et al.* 2001).

The departure from traditional single-species management has profound implications for DFO and forms a significant policy overlap with Parks Canada as specified in the proposed *Canada National Marine Conservation Areas Act* and operational policies (Parks Canada 1994). Moreover, there are the accepted recommendations of the Report of the Panel on the Ecological Integrity of Canada's National Parks (Parks Canada Agency 2000) and the commitment to ecological integrity in the amended *Canada National Parks Act* (2000) that will influence management of marine conservation areas. Both agencies are actively developing ways to implement this ecosystem-based policy change and Gwaii Haanas will be a national marine benchmark site for such cooperation and implementation. Perry (1999) has outlined the following concepts critical to managing human activities, such as shellfish fishing, within marine ecosystems:

- declare the goals for ecosystem-based management;
- define time and space scales for ecosystems;
- recognize the large uncertainties;
- identify appropriate "control levers" such as habitats particularly sensitive to human impacts with traditional and innovative management tools; and
- start in modest increments, but start NOW.

The application of these ideas will influence future shellfisheries management within Gwaii Haanas.

The Shellfish Advisory Process: Science and Consultation

Because so many Pacific invertebrate species are potential fisheries targets and so little is known about their biology, DFO has developed a scientific advisory framework for providing management advice for new and developing shellfisheries (Perry *et al.* 1999). This framework does the following:

- endorses the precautionary approach;
- identifies science information needs according to differing management strategies;

- recognizes the importance of sedentary to mobile life history patterns;
- underscores the critical nature of cooperation among stakeholders; and
- outlines a three-phased approach to obtaining scientific information for sound management of target species.

The three phases in Perry *et al.* (1999) are as follows:

- "Phase 0" – assembling all available information on the target species and developing alternative regulatory strategies;
- "Phase 1" – gathering new information lacking from the Phase 0 review and evaluating the regulatory strategies proposed during Phase 0; and
- "Phase 2" – to implement the selected management strategies from Phase 1 during commercial fishing to refine scientific data and provide inseason fishing and stock information if regulation of fishing effort is a management goal.

Fisheries and Oceans Canada has a regionally-based Shellfish Coordinator to expedite consultation, policy formulation and science-based management implementation including the annual cycle of fishing plans and reviews of regulatory changes. This is the nexus of First Nations, industry, coastal community and multi-agency science inputs.

The science advisory process involves two in-house DFO committees; the Shellfish Working Group and the Invertebrates Subcommittee of the Pacific Scientific Advice Review Committee (PSARC), discussed below. The Shellfish Working Group consists of DFO staff that prepare each fishery's Integrated Fishery Management Plan whose format was developed in 1999. These plans are comprehensive documents that provide one-stop-shopping on policy and management for that fishery. Plans include goals and objectives, the species' life histories, a historical fishery overview, enforcement plan, plans for all fishery types and all regulations and conditions of the licence for that year. These are the responsibility of the management biologist assigned to the fishery. Management biologists also prepare PSARC Fishery Updates that are the annual post-season summary of that fishery available from the PSARC Secretariat. These also include species' life history (biology and ecology) overviews. Management plans are lodged with the DFO internet site:

http://www.pac.dfo-mpo.gc.ca/ops/fm/mplans/mplans.htm

Consultative arrangements with commercial, recreational, provincial government, non-government and First Nations sectors enable broad-scale participation with DFO in fishery management. The consultation cycle begins with the annual presentation of "draft" management plans from DFO. There are 12 Shellfish Sectoral Committees, one for each of the management plans drafted by shellfish managers [geoduck / scallop (dive) / clam (intertidal) / octopus (dive) / opal squid / crab / prawn-shrimp (trap) / shrimp (trawl) / euphausiid / red sea urchin / green sea urchin / sea cucumber]. These are not voting bodies, but rather advisory bodies providing input from the relevant industry association to the fishery managers and eventually to the DFO regional (Pacific) Director General for signing of the management plans. For example, the primary consultative body for recreational fisheries, the Sport Fishing Advisory Board, has a seat on Sectoral Committees along with First Nations and the relevant commercial associations. Notices of Sectoral Committee meetings are available through the internet at:

http://www-ops2.pac.dfo-mpo.gc.ca/fnsreports/rptmain.cfm

Further, DFO consults with individual First Nations in separate, informal bilateral processes to ensure that the unique constitutional rights of First Nations with fishery resources are addressed. The Haida Nation has one of the few structured, joint shellfish technical committees that meet with DFO on local shellfish issues. End-points of all these consultation processes are the Integrated Fishery Management Plans.

Management and Information Sources

Fishers hunt for the market and, as such, they represent one of the last vestiges of hunting/gathering; ancient human occupations pre-dating agriculture. Yet, modern fisheries are information-intensive and often rely on high technology tools.

North coast of British Columbia management responsibility for enforcement, regulation, licensing and habitat management resides with the Resource Management Branch, Coastal British Columbia North in Prince Rupert. For Haida Gwaii, there is staff at district offices in Queen Charlotte City and Masset. Regulatory enforcement and implementation of fishing plans are done by six district fishery officers in Haida Gwaii.

Critical to fisheries management are the types of information, including statistics, yielded from the industry, their contractors and agencies both in-season and post-season. Information on individual shellfisheries comes from fishers' *"harvest logs"* maintained daily as a mandatory part of their licence responsibilities and the dockside and fishery-independent surveys by DFO, commercial industry associations (or their service bureau [contractors]), and First Nations. Commonly among the shellfisheries, a contract exists between an industry association and a private sector service provider which mirrors requirements set out in a collaborative agreement between the industry association and DFO. Rarely are there contracts for such services directly between DFO and the service provider. In individual quota fisheries, dockside monitoring and validation is executed by DFO-certified contractors in cooperation with the industry. From the fishing grounds in-season, fishers make radio or phone *"hail-in"* calls to advise DFO or a contractor where they are going and when they switch sub-areas in which they will be fishing. Hail-in procedures vary between fisheries. Fishers may also hail when and where they are going to land product at designated landing sites with the approximate amount (weight or pieces). This information goes to DFO from the contractor on a real-time basis so that DFO knows the movement and fishing progress of the fleet. Some fisheries also have on-ground observers to monitor fishery progress and regulatory compliance. These data sources can be critical, especially later in-season when individual quotas or area quotas are approaching their target amounts and DFO must prepare for specific area closures.

The commercial *"fish"* or *"sales"* slip system is a means for gathering catch, rudimentary effort (e.g., trip duration) and value information from fisheries. Official DFO estimates of catch continue to be derived from sales slips. Fishers or commercial buyers must generate sales slips whenever catch is sold, given away, used domestically or discarded (e.g., spoiled). Often, slips are completed at dockside by the buyer. Product information can also come from processors. If a fisher does his or her own dockside sales (e.g., prawns), then the fisher is responsible for submitting slips. Sales slip information does not enable distinguishing between near-shore and offshore fishing. Species information pertains to target species only. Data on nontarget species landings and discards are not reported. Gear information is generalized. A single entry in this system most often represents a single transaction between the fisher and a buyer. Sales slip data are cross-referenced against alternate independent sources of catch information in "*validation logs*" that enable assessment of data quality and completeness.

Fishers provide harvest logs recording detailed catch and fishing effort data (e.g., kg per diver hour for geoduck) expended at all fishing locations. This is done on a schedule provided in the conditions-of-license; usually within 28 days of the end of the month in which fishing occurred. Logbook programs were introduced from 1978 to 1990 according to shellfishery. Unlike the sales slip system, value and buyer information is not collected.

In the late 1990s, red sea urchin, green sea urchin, sea cucumber and geoduck fisheries adopted individual quota management. This required 100% dockside validation. The validation programs were combined with logbooks, yielding the validation logs containing very accurate catch data. For non-validated fisheries, harvest logs are compared to alternate independent sources of catch information (e.g., shrimp trawl landings records) to give an assessment of the quality and completeness of the data, similar to the sales slip system.

Logbook data are detailed; for some fisheries a single entry represents a single dive and captures when, where and for how long the dive occurred and how much was fished. For other fisheries, a single entry represents a string of traps or a single tow and how long the gear was deployed in a specific location at a particular time and the yield. Logbooks yield species information, both for the targeted species and for those species fished incidentally ("bycatch"). Gear specifications are also recorded.

Location of fishing is most commonly described as per Pacific Fisheries Management Area (PFMA) sub-area, or particular management area as for geoduck, thus demarcating between nearshore and offshore fishings. Fishing log location data include either latitude and longitude or maps showing locations of specific fishing events for some fisheries. Some data are held protected by DFO as mandated under the *Access to Information Act* and the *Privacy Act*. This protects each individual fisher's fishing site data. Also, if fewer than three fishers record from a PFMA sub-area within a season for a particular species, those data are confidential - as revealed in some landings tables provided later.

Pacific Fisheries Management Areas (PFMAs)

To facilitate local area management and enable georeferencing (putting geographic reference to) fishing data and management directives, the coast is coarsely divided by DFO into Pacific Fisheries Management Areas (PFMAs) and, within these, into PFMA sub-areas. The PFMAs of the northern British Columbia coast are north of Cape Caution (Figure 22). The major inshore PFMAs of Haida Gwaii (1, 2 [E and W]) are separated from the offshore PFMAs (101, 102, 130, 142) by the arbitrary "surfline". Nearshore Gwaii Haanas is represented within PMFA 2 (E and W). Most invertebrate fishing occurs nearshore, that is, landward of the surfline.

Each PFMA is divided into sub-areas. These were originally designed for finfish, especially salmonid, management. The sub-areas south of Skidegate Inlet including all of nearshore Gwaii Haanas (23 sub-areas) are shown in Figure 23. The sub-areas of Skidegate Inlet northward including Graham Island are shown in Figure 24. The

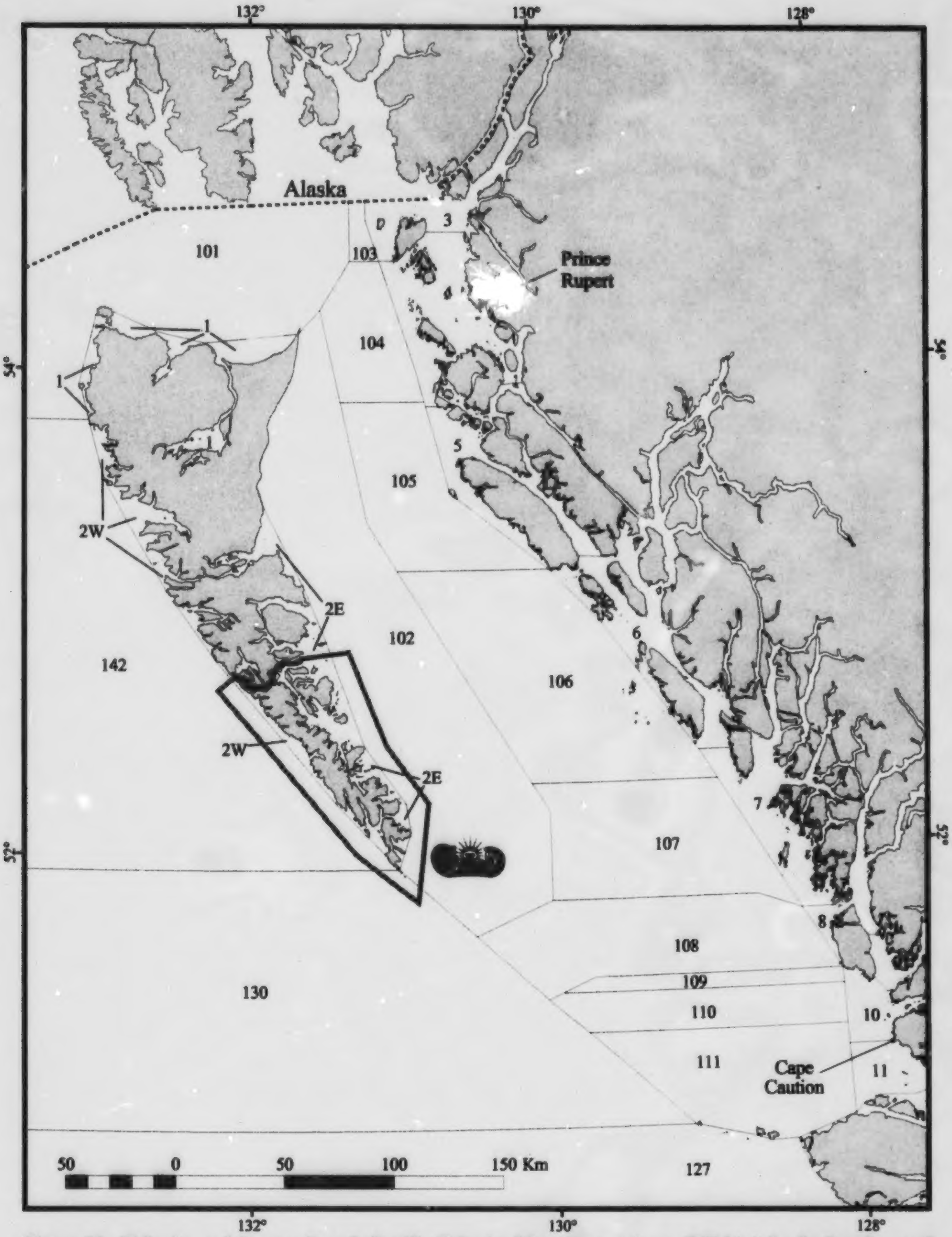
132°
130°
128°
Alaska
101
103
3
Prince Rupert
104
1
1
54°
5
105
2W
2E
102
142
106
6
2W
2E
7
52°
107
8
108
109
110
10
130
111
Cape Caution
11
50
0
50
100
150 Km
127

Figure 22. Fisheries and Oceans Canada Pacific Fisheries Management Areas (PFMAs) for the "north coast" of British Columbia, north of Cape Caution (PFMA boundary file courtesy of B. Mason and M. Manson, DFO).

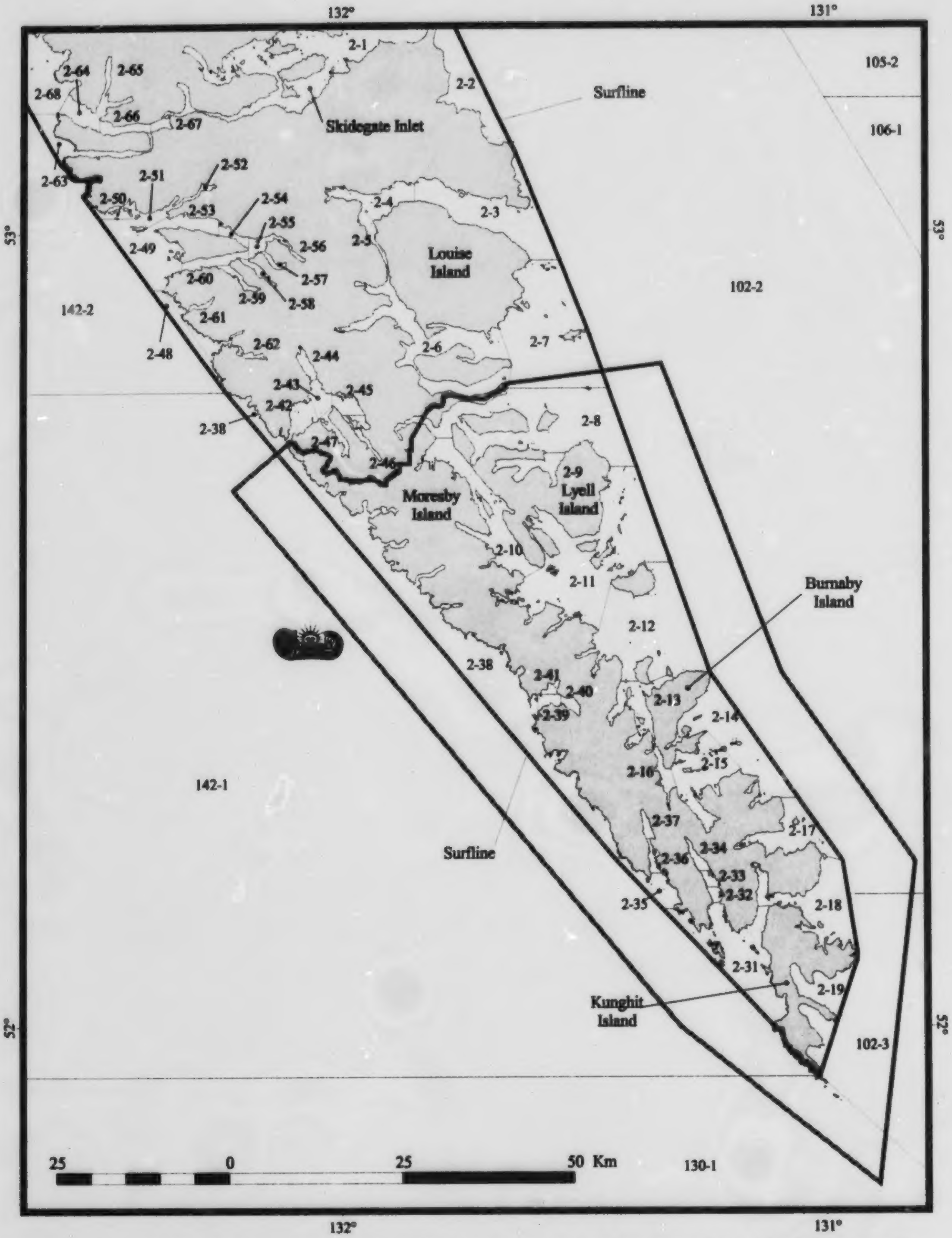
132°
131°
53°
52°
2-1
2-2
105-2
106-1
Surfline
2-64
2-65
2-68
2-66
2-67
Skidegate Inlet
2-63
2-51
2-52
2-50
2-53
2-54
2-55
2-56
2-5
2-4
2-3
2-49
Louise Island
2-60
2-57
2-59
2-58
102-2
142-2
2-61
2-48
2-62
2-44
2-6
2-7
2-43
2-45
2-42
2-38
2-8
2-47
2-46
2-9
Moresby Island
Lyell Island
2-10
2-11
Burnaby Island
2-12
2-38
2-41
2-40
2-13
2-39
2-14
2-15
2-16
142-1
2-37
2-17
Surfline
2-34
2-36
2-33
2-32
2-35
2-18
2-31
Kunghit Island
2-19
102-3
25
0
25
50 Km
130-1

Figure 23. Pacific Fisheries Management Area (PFMA) sub-areas and surfline (shown in bold) of Haida Gwaii for the region south of Skidegate Inlet including Gwaii Haanas (PFMA boundary file courtesy of B. Mason and M. Manson, DFO).

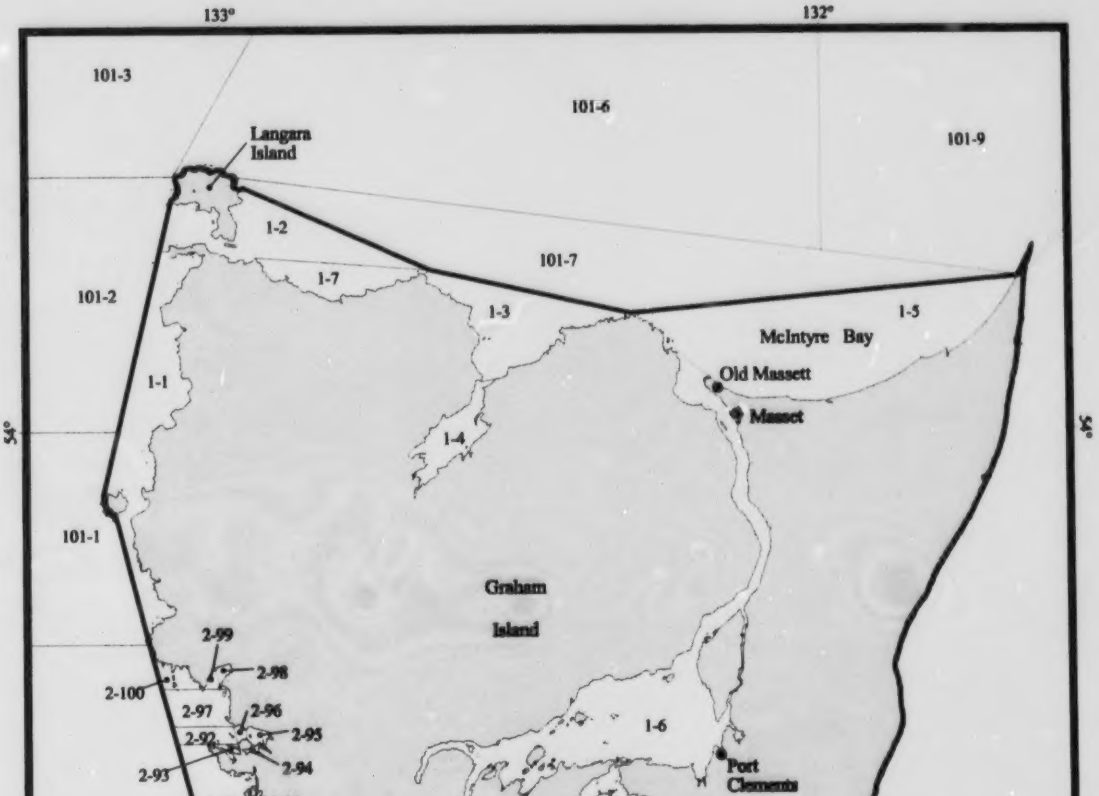
133°
132°
101-3
101-6
101-9
Langara Island
1-2
101-7
1-7
101-2
1-3
1-5
McIntyre Bay
Old Massett
1-1
Masset
54°
1-4
101-1
Graham Island
2-99
2-98
2-100
2-97
2-96
2-95
2-92
2-94
2-93
1-6
Port Clements
2-88
2-89
2-91
Tlell
2-90
2-87
2-84
102-1
2-83
2-85
2-82
2-81
2-86
2-79
2-73
142-2
2-75
2-78
Surfline
2-76
2-74
2-72
2-77
2-70
Surfline
2-69
Queen Charlotte City
Skidegate
2-71
2-1
Sandspit
2-68
2-64
2-65
2-66
2-67
2-63
Skidegate Inlet
Moresby Island
10
0
10
20
30 Km
133°
132°

Figure 24. Pacific Fisheries Management Area (PFMA) sub-areas and surfline (shown in bold) of Haida Gwaii for the region of Skidegate Inlet and northward including Langara Island (PFMA file courtesy of B. Mason and M. Manson, DFO).

sub-areas provide a finer scale at which catch statistics such as amount of fishing and fishing effort can be made.

For shellfish management on the north coast with location-specific stocks of, for example, geoduck clam (*Panope abrupta*) and red sea urchin (*Strongylocentrotus franciscanus*), *"area management"* is used. Area management is described in management plans and implemented on the fishing grounds. Area management permits the allocation of quota according to the reality of geoduck or red sea urchin distribution. Examples are illustrated in Figures 25 and 26 in which geoduck and red sea urchin fishing areas respectively are superimposed over sub-area boundaries. These superimposed polygons reflect the best current knowledge from stock assessment surveys and, therefore, the spatial realities of these species for these fishing areas. Management area descriptions may, therefore, vary over time as new stock assessment data become available. This could complicate spatial analyses of time series. In summary, although DFO is committed to the PFMA and sub-area schemes for reporting landings and issuing management directives, there is the flexibility for area management that could vary on an annual basis. Sub-areas are not, therefore, always the finest scale at which DFO manages shellfisheries for tracking quota, openings, closures and other management directives to industry.

Stock Assessment and Research

"…. there is always some irreducible level of uncertainty, which cannot be attenuated by any increase of scientific knowledge." (Orensanz and Jamieson 1998)

"…. worse than uncertainty itself is the fact that we tend to underestimate uncertainty. (Parma *et al.* 1998)

Technical and research support is provided mainly from the Stock Assessment Division of DFO's Science Branch at the Pacific Biological Station, Nanaimo. The DFO forum for assessments, technical advisory and management papers, called Invertebrate Working Papers, is the Invertebrate Subcommittee of PSARC. These papers are the scientific basis for regional fisheries management. Papers are solicited, subjected to peer review (by both DFO and non-DFO experts) and presented semi-annually (usually June and December) by DFO staff, contractors to industry associations, or other stakeholders for the Invertebrate Subcommittee. Most often, studies are *"accepted pending revision."* When revision is completed, and the Subcommittee reaches consensus on the study's recommendations, the paper is accepted for publication. Until 1998, papers were compiled into issues of the *Canadian Technical* (or *Manuscript*) *Report of Fisheries and Aquatic Sciences* series. Now, papers are forwarded to the DFO Canadian Stock Assessment Secretariat in Ottawa and made available on their internet site:

http://www.dfo-mpo.gc.ca/csas

As well, some accepted papers may be forwarded by the PSARC Steering Committee to the Pacific Region Management Executive Committee for consideration and decision-making. In recent years, the PSARC process has broadened to include industry observers and additional stakeholders. For example, Pacific Rim National Park, Gwaii Haanas and the Haida Fisheries Program have representatives on the Invertebrate Subcommittee. Another internet site for DFO research documents is:

http://www.pac.dfo-mpo.gc.ca/sci/psarc/resdocs

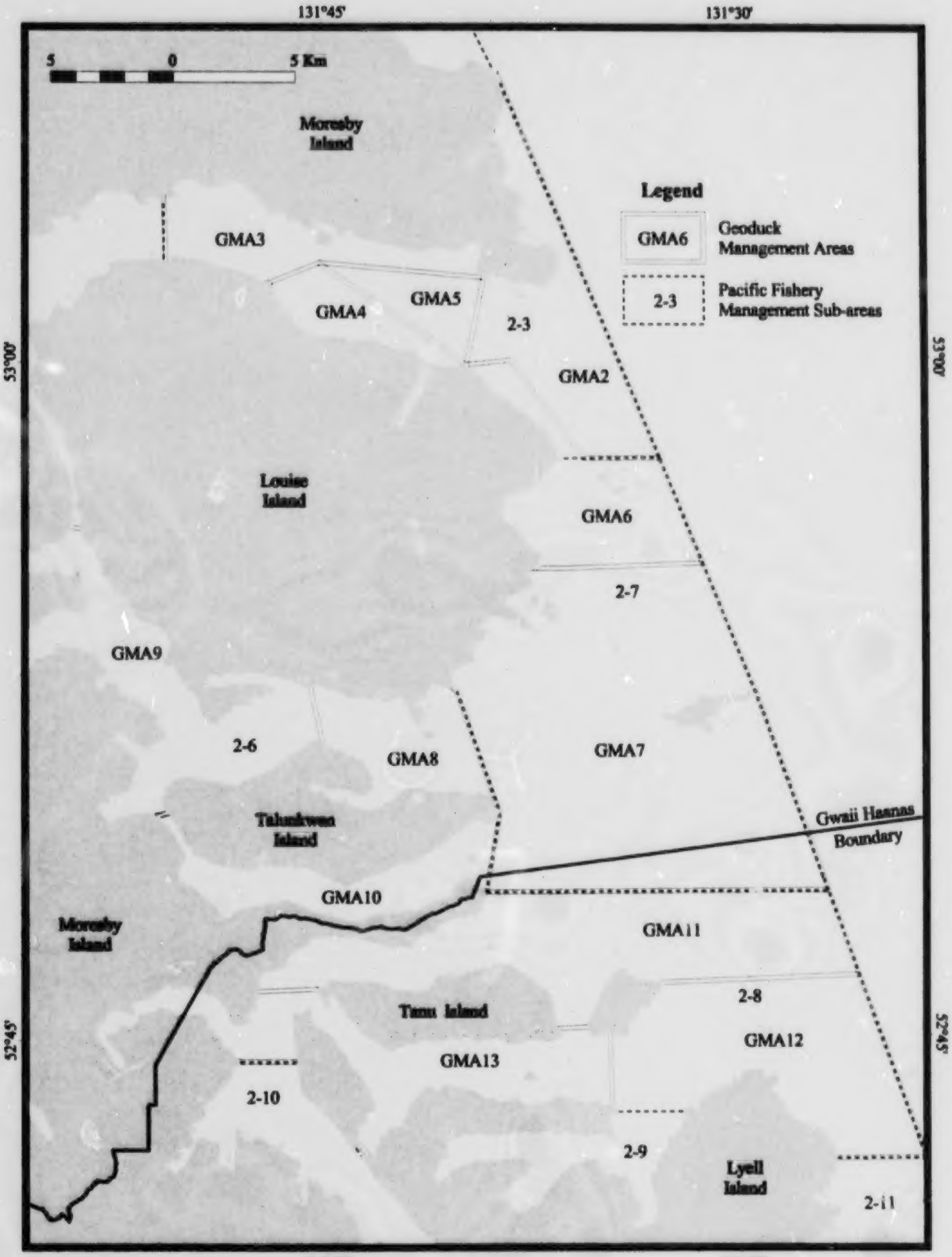
131°45'
131°30'
5
0
5 Km
Moresby Island
Legend
GMA6
Geoduck Management Areas
2-3
Pacific Fishery Management Sub-areas
GMA3
GMA4
GMA5
2-3
GMA2
53°00'
53°00'
Louise Island
GMA6
2-7
GMA9
2-6
GMA8
GMA7
Tahunkwan Island
Gwaii Haanas Boundary
GMA10
Moresby Island
GMA11
2-8
Tanu Island
GMA12
52°45'
52°45'
GMA13
2-10
2-9
Lyell Island
2-11
131°45'
131°30'

Figure 25. An example of "area management " polygons for geoduck superimposed over PFMA sub-area boundaries in the Louise to Lyell Islands area of Gwaii Haanas (data courtesy of J. Rogers, DFO).

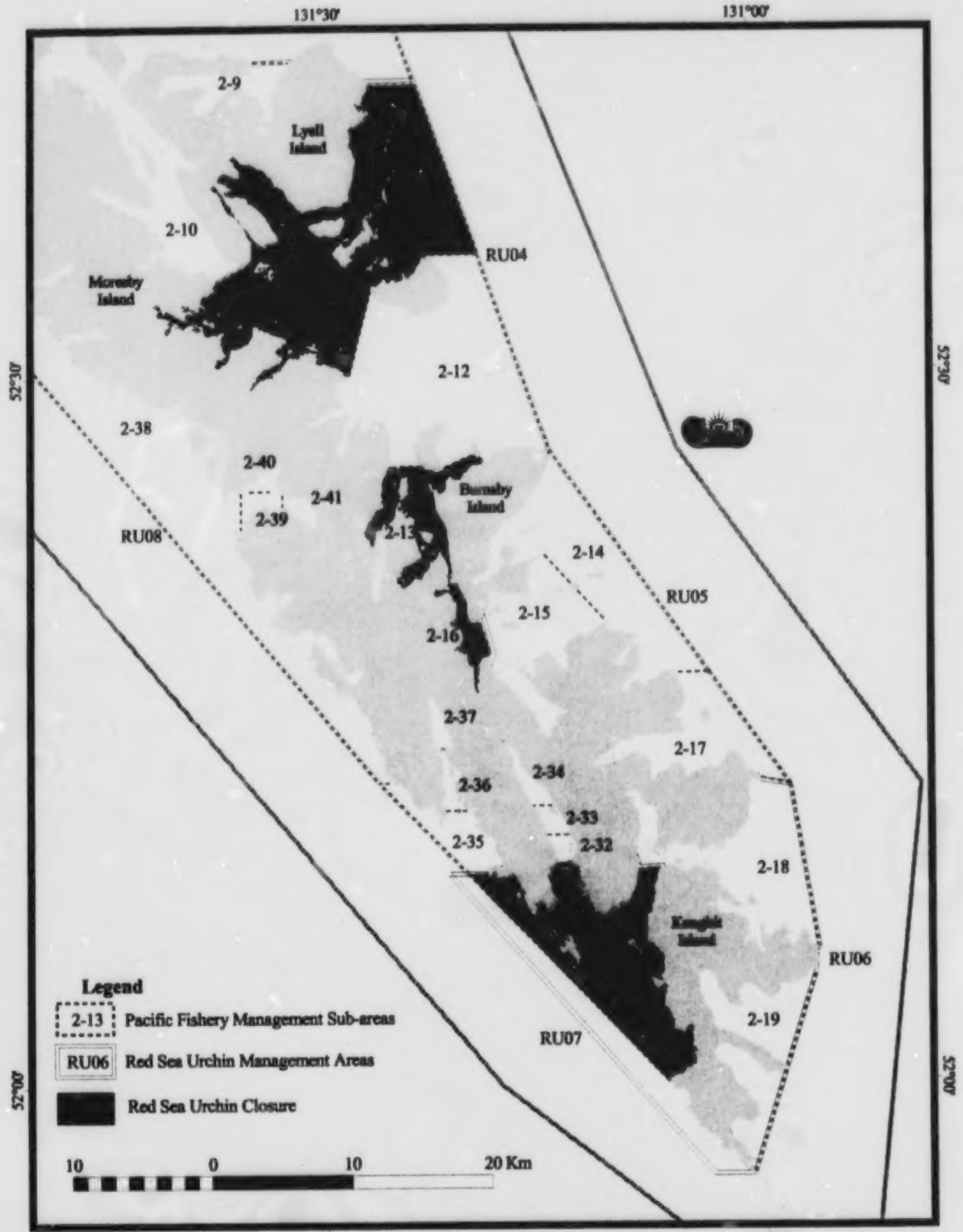
131°30'
131°00'
2-9
Lyell Island
2-10
Moresby Island
RU04
2-12
52°30'
52°30'
2-38
2-40
2-41
2-39
RU08
Burnaby Island
2-13
2-14
RU05
2-15
2-16
2-37
2-17
2-36
2-34
2-33
2-35
2-32
2-18
Kunghit Island
RU06
Legend
2-13 Pacific Fishery Management Sub-areas
RU06 Red Sea Urchin Management Areas
Red Sea Urchin Closure
2-19
RU07
52°00'
52°00'
10
0
10
20 Km
131°30'
131°00'

Figure 26. An example of "area management" polygons for red sea urchin superimposed over PFMA sub-area boundaries in the southern Gwaii Haanas area (data courtesy of J. Rogers, DFO).

The scientific advice provided through the PSARC process is just that – advice. Fisheries managers take this advice into consideration along with other information and concerns. Accessing science remains a core management attribute, but when discussing science input into management, it is important to state the caveat that science will unlikely ever account for all of the uncertainty associated with stock assessments and predictions. Our understanding of basic ocean ecology processes remains rudimentary. Living with uncertainty means, therefore, that the way forward is through humility, consultation with stakeholders bringing different information types to the table and using prudence and the precautionary approach when weighing these information types in open consultation.

HAIDA FISHERIES PROGRAM

Shellfish stock assessments (except crab and prawn) executed in Haida Gwaii are cooperative ventures between the industry, DFO and the Haida Fisheries Program of the Council of the Haida Nation (CHN). Further, in scientific aspects of stock assessments and management, there is a bilateral CHN/DFO Joint Shellfish Technical Committee co-chaired by the Haida Fisheries Program and DFO. In this forum, DFO advises on the appropriate science needed according to the management problems tabled by the committee. Particularly in the case of the razor clam (*Siliqua patula*) fishery, management decisions are made through the Haida Fisheries Program (HFP) in cooperation with DFO.

The HFP, initiated in 1989 with federal seed funding, answers to the CHN. In the fiscal year 1999-2000, the HFP had a budget exceeding $ 2.2 million with 11 full-time and over 30 part-time staff. Funding in 2000 was ≈52% from DFO's Aboriginal Fisheries Strategy and the balance from 11 other sources, indicating broad support for the Program. The HFP activities include managing vessels and commercial licences, operating a salmon hatchery (Pallant Creek), environment and fishery monitoring, regulatory enforcement, stock assessment and cooperative scientific research. For example, the CHN fields Fisheries Guardians with basic training equivalent to DFO Fishery Officers. The Guardians participate on joint patrols with DFO as well as executing independent surveillance and enforcement tasks. Concerning the co-managed intertidal razor clam fishery on North Beach, 2000 was the sixth year of the co-management agreement with DFO described by Jones and Garza (1998). Haida tasks include participation in management plan formulation, enforcement, compiling catch statistics, stock assessment (Jones *et al.* 1998), and facilitating for monitoring of paralytic shellfish poison.

Although there are no Haidas currently licensed to fish geoduck clam or red sea urchin, the HFP participates in their stock assessment and research in Haida Gwaii. Annually from 1992 to 1998 the HFP conducted red sea urchin stock surveys in cooperation with DFO and the Pacific Urchin Harvesters' Association. As well, research plots were subjected to controlled red sea urchin fishing in the Cumshewa Inlet and Selwyn Inlet areas in 1996 in cooperation with DFO scientists. The plots have been monitored in subsequent years to evaluate effects of thinning on red sea urchin roe yield and tag-recapture studies for growth estimates. As well, traditional Haida knowledge has been gathered to support applications to DFO for closing selected commercial red sea urchin locations to facilitate Haida fishing for food, social and ceremonial purposes.

The HFP dive team also executes geoduck stock assessments in cooperation with DFO and the Underwater Harvesters' Association. By 1999, six consecutive annual surveys were completed and ≈46% of geoduck beds are now known in the Haida Gwaii area. Survey design, data entry and analyses are provided by DFO. The HFP dive team executes the field protocol with industry. The HFP has access to all stock assessment data, but does not have access to fishers' logbook data or their maps of beds. These are held by DFO.

The HFP also surveys northern abalone stocks in cooperation with DFO. For example, stocks in Virago Sound were assessed in 1999. Other abalone initiatives include collecting genetic samples in support of DFO stock identification and some tag-recapture work for growth studies. Finally, the HFP and DFO are also committed to developing a consultation process for initiating new fisheries (e.g., Tanner crab [*Chionoecetes* spp.]) or expanding small fisheries (e.g., octopus [*Enteroctopus dofleini*]).

It is interesting to reflect on the social evolution of Haida commercial use of shellfish. In 1787, while at anchor in the Houston Stewart Channel, the *Prince of Wales* was supplied with *"plenty of …clams"* by Haida (James Colnett in Acheson 1998). This is the first recorded commercial transaction involving shellfish between the Haida and Europeans. In the early 20th century, Haidas fished for, and laboured in, various historic shellfish operations such as Canada's first crab cannery in Naden Harbour and at the Bag Harbour clam cannery (Seaman 1951; Jones and Lefeaux-Valentine 1991; Morton 1992). In 1994, one of the first co-operative shellfish management partnerships between a First Nation and DFO in British Columbia was the Haida-DFO management agreement for the intertidal razor clam fishery on North Beach (Harbo 1998; Jones and Garza 1998) and described in detail below. The Haida Fisheries Program receives scientific management advice from DFO, but the program executes stock assessment and day-to-day management of the commercial fishery. This marks a return, after two centuries, to indigenous responsibility for a Haida Gwaii marine invertebrate.

RECREATIONAL INVERTEBRATE FISHERIES

A number of invertebrate species are available to recreational ("sport") fishers in Haida Gwaii. All sport fishers must have a *British Columbia Tidal Waters Sport Fishing Licence*. The current regulations for the four main sport fisheries are provided in Table 14 and in the *British Columbia Tidal Waters Sport Fishing Guide* available on the DFO Pacific Region web page:

http://www.pac.dfo-mpo.gc.ca/

The most actively managed recreational fishery is for razor clam on North Beach, McIntyre Bay (Figure 24). This fishery requires regular paralytic shellfish poison (PSP) biotoxin testing. The area also has post-storm picking of beached weathervane scallop (*Patinopecten caurinus*). Other appreciable sport fisheries include Dungeness crab (*Cancer magister*) and prawn (*Pandalus platyceros*) throughout the archipelago where these species occur. No data are routinely collected on any sport shellfishery in Haida Gwaii. Therefore, effects of this fishery on stocks are unknown and little regulated (Foster 1989). The main management issue is ensuring public health and safety given the potential PSP biotoxin threats from bivalves (clams, mussels, cockles and scallops), and perhaps domoic acid in Dungeness crab, as described in the public health section below.

Table 14. Main recreational ("sport") invertebrate fisheries of Haida Gwaii.

Species[1]	Comments on Gear, Habitat, Current Regulations
Dungeness Crab[2] (*Cancer magister*)	Trap (shallow-water)- wherever suitable sandy habitat occurs (mostly from Sandspit northward), open year-round, legal size 165 mm carapace (shell) width (male or female), limit of 2 traps per fisher, traps marked with licencee's name and phone number, daily bag limit of 6, possession limit of 12
Prawn[2] (*Pandalus platyceros*)	Trap (deep-water) - wherever suitable habitat occurs, open year-round, no minimum legal size, 4 traps per fisher, traps marked with licencee's name and phone number, daily bag limit of 5 kg (head-on) / 2 kg (head-off), possession limit of 10 kg (head-on) / 4 kg (head-off)
Weathervane Scallop (*Patinopecten caurinus*)	Intertidal picking on North Beach, Graham Island (PFMA sub-area 1-5) particularly after winter storms, open year-round, daily bag limit of 100, possession limit of 200
Razor Clam (*Siliqua patula*)	Intertidal digging on North Beach, open year-round (after PSP testing), no size limit, daily bag limit of 75, possession limit of 150

1 no data, such as landings statistics (weight or area), are recorded from the recreational shellfisheries

2 a brief *Stock Status Report* for this species or group, intended for the general public, is available from the Canadian Stock Assessment Secretariat of DFO at: http://www.dfo-mpo.gc.ca/csas/csas/status/Invert.htm

COMMERCIAL INVERTEBRATE FISHERIES

This review updates the first regional shellfisheries compilation, up to 1989, commissioned by Parks Canada (Jones and Lefeaux-Valentine 1991). Firstly, the five species (Table 15) comprising the major shellfisheries in terms of landings, value and regional economic importance are discussed immediately below. Secondly, the closed, minor or experimental species (Table 16) are then described, more briefly, with the exception of northern abalone. The text for each species begins with some key life history characteristics including guidance to the species' main science references. The fishery management plans for each species contain more extensive life history information. Also included are notes on effects of sea otter predation on each species in support of a general discussion on sea otter-shellfisheries interactions that follows. Biological information is followed by fisheries and management information.

Razor Clam

British Columbia's largest stock and only commercial intertidal digging fishery for razor clam (*Siliqua patula*) occurs on North Beach (McIntyre Bay), Graham Island. The species is restricted to exposed, high wave-energy sand beaches. As with all commercial bivalve molluscs, razor clams are filter-feeders of plankton.

Although sea otters are known to prey upon razor clams in Alaska, Washington and California, their effects at the population level are unknown (Watson and Smith 1996). Therefore, it is speculative whether the North Beach fishery would be threatened if sea otters were to eventually reoccupy the area.

Since 1994, the fishery has been cooperatively managed between the Haida Nation and DFO. This was one of the first co-operative shellfish management partnerships between DFO and a First Nation (Harbo 1998). Razor clam life history, fishing history, stock assessment

Table 15. Major commercial invertebrate fisheries of Haida Gwaii.

Species	Comments on Gear, Habitat, Management Issues	First Year of Recorded Landings	References
Razor Clam (*Siliqua patula*)	Intertidal digging only on North Beach, McIntyre Bay, Graham Island (PFMA sub-area 1-5), co-managed between HFP and DFO	1923	Jones *et al.* (1998), Jones and Garza (1998)
Geoduck Clam[1] (*Panope abrupta*)	Diver-taken[2]- sand habitat is modified by water-pressure "stinger" used to dislodge clams – stock assessment is collaborative between HFP, DFO and Underwater Harvesters' Association	1980	Campbell *et al.* (1998)
Red Sea Urchin[1] (*Strongylocentrotus franciscanus*)	Diver-taken[2] – associated with kelp forests on rocky bottoms – stock assessment is collaborative between HFP, DFO and Pacific Urchin Harvesters' Association	1984	Campbell (1998), Campbell *et al.* (1999)
Dungeness Crab[1] (*Cancer magister*)	Trap (shallow-water) – sandy areas mostly around east and north coasts of Graham Island and north western Hecate Strait	1933[3]	Boutillier *et al.* (1998 a)
Prawn[1] (*Pandalus platyceros*)	Trap (deep-water) – steep-sided inlets, includes incidental catch of humpback shrimp (*Pandalus hypsinotus*)	1980	www.pac.dfo-mpo.gc.ca/ops/fm/shellfish/prawn

1 a brief *Stock Status Report* for this species, intended for the general public, is available from the Canadian Stock Assessment Secretariat of DFO at: http://www.dfo-mpo.gc.ca/csas/csas/status/Invert.htm

2 usually <35 m depth

3 landings at least since 1919 (I.Winther, DFO, *personal communication*)

and current fishery management are detailed in Jones and Garza (1998) and Jones *et al.* (1998), so only an overview is provided here.

The recorded fishery dates from the 1920s with biological assessments beginning in 1928 (Fraser 1930). This fishery is economically and culturally important to the Old Massett band of the Haida Nation. In this limited entry fishery, diggers (mostly Haida), receive licences from the CHN. There are six non-Haida diggers "grandfathered" in because of their pre-1994 history in the fishery. All new licences are restricted to Haida only. Until 2000, there was no individual catch quota and no restriction on the number of licensed diggers. The commercial product has mostly been for bait rather than seafood. A 1994 assessment estimated a fishable razor clam stock of ≈5.8 million clams (≈636 metric tonnes [t]) and an annual sustainable amount of ≈118 t (Jones *et al.* 1998).

Landings of legal-sized clams (90 mm shell length) fluctuate according to market demand. Between 1995 to 1999, annual landings averaged 84.9 t (range 39 to 128 t). Partway through the 1999 season, a seafood market developed. In response to this opportunity, landings increased in 2000 until, by August, they exceeded 230 t and the fishery was closed for conservation purposes. The HFP is now faced, for the first time in a commercial fishery, with implementing the annual allowable catch through decreasing fishing effort by limiting entry of Haida diggers. There were 269 licensed Haida diggers in 2000.

Table 16. Closed, minor, or intermittent commercial invertebrate fisheries of Haida Gwaii.

Species/Group	Harvest Method and Management Notes	References
Northern Abalone (*Haliotis kamtschatkana*)	Total, coast-wide closure since 1990 due to low stocks – remains closed as stocks are not rebuilding	Sloan and Breen (1988), Wallace (1999), Jamieson (1999), Campbell (2000)
Horse Clams (*Tresus nuttallii / Tresus capax*)	Diver-taken - small incidental catch from geoduck fishery – concerns for minimizing sea grass meadow habitat damage in the shallow subtidal	Lauzier *et al.* (1998)
Butter Clam (*Saxidomus gigantea*)	Intertidal digging – no landings since the 1980s	Quayle and Bourne (1972), Gillespie and Bourne (1998)
Native Littleneck Clam[1] (*Protothaca staminea*)	Intertidal digging – no landings since the 1980s	Quayle and Bourne (1972), Gillespie and Bourne (1998)
Octopus (*Enteroctopus dofleini*)	Diver-taken, trap and bycatch in crustacean trap and finfish bottom trawl fisheries – trap licence discontinued in 1999	Gillespie *et al.* (1998)
Neon Flying Squid[1] (*Ommastrephes bartrami*)	Offshore jigging – still an "experimental" fishery	Sloan (1991), Gillespie (1997)
Opal Squid[1] (*Loligo opalescens*)	Inshore seine - no landings since 1988	Bernard (1980)
Red Squid (*Berryteuthis magister*)	Finfish bottom trawl bycatch	Bernard (1980)
Shrimp[1]: Pink (*Pandalus borealis*), Humpback (*Pandalus hypsinotus*), Sidestripe (*Pandalopsis dispar*)	Beam and Otter bottom trawls – possible trawl damage on sea bottom	Boutillier and Joyce (1998), Boutillier and Nguyen (1999), Boutillier *et al.* (1999)
King Crab (*Paralithodes camtschatica*)	Trap (moderate depth) – no landings since 1996	Jamieson and Sloan (1985)
Goose Barnacle[1] (*Pollicipes polymerus*)	Intertidal hand-picking on exposed rocky shores – no landings since 1994	Bernard (1988), Lauzier (1999 a,b), Jamieson *et al.* (1999)
Green Sea Urchin (*Strongylocentrotus droebachiensis*)	Diver-taken – no landings since 1990	Perry and Waddell (1999)
Sea Cucumber[1] (*Parastichopus californicus*)	Diver-taken – no landings since 1995	Boutillier *et al.* (1998b), Phillips and Boutillier (1998), Hand and Rogers (1999)

[1] a brief *Stock Status Report* for this species or group, intended for the general public, is available from the Canadian Stock Assessment Secretariat of DFO at: http://www.dfo-mpo.gc.ca/csas/csas/status/Invert.htm

Of all the Haida Gwaii shellfisheries, the razor clam fishery is executed with the greatest degree of local control. Further, there are sport and Aboriginal food fishery landings. Both these and the commercial fishery depend upon the opening being maintained by DFO based on weekly PSP testing results reported from the Canadian Food Inspection Agency.

Geoduck Clam

The geoduck (*Panope abrupta*) is a remarkable creature. It is the world's largest infaunal (burrowing) clam, weighing up to ≈4 kg, living at up to 0.9 m in the sediment and attaining ages >160 years (an individual from Tasu Sound; C. Hand, DFO, *personal communication*). Average weight of marketed geoduck is ≈1 kg. Geoduck beds can occur in sandy habitats ranging from the low intertidal to >110 m depth. In some areas, bed density increases gradually with depth to ≈25 m. Sexes are separate and adults broadcast millions of eggs and sperm into the water column for fertilization in spring-early summer. Maturity is reached in approximately six years and clams spawn annually, perhaps for over a century. However, the dense beds of (old) clams indicate low adult mortality and low rates of juvenile recruitment (Goodwin and Pease 1991; Orensanz *et al.* 2000). The few of the billions of larvae that do survive have low mortality rates only if individuals become safely interred in sediment. Geoducks, however, are not like forest trees that grow continuously. Geoduck growth is very rapid early in life (most growth occurs within ≈10 to 12 years of age), but is very slow thereafter. A major concern about geoduck is that shell aging, coast-wide, has revealed populations dominated by older clams (e.g., Noakes and Campbell 1992), with little significant recruitment since the 1970s (Orensanz *et al.* 2000). However, a forthcoming study involving unpublished age and size data of >12,800 geoducks from 34 locations (not used in Orensanz's work) reveal higher proportions of younger clams. This includes examples of what may have been a dramatic recruitment event within approximately the last decade of sampling at Hippa Island (surveyed in 2000) and other, less dramatic, recruitment events near Hotsprings Island (surveyed in 1995), in Cumshewa Inlet (surveyed in 1997) and in Gowgaia Bay (surveyed in 2000) (Bureau *et al. in preparation;* D. Bureau and C. Hand, DFO, *personal communication*). Overall, however, although there may now be less concern over the poor recruitment, the species' life history is largely a mystery with a particularly poor understanding of population replenishment.

Watson and Smith (1996) are uncertain about the effects of sea otters on geoduck. Although sea otters will dig geoduck, the effects of this predation at the population level are unknown. Where investigated, geoduck densities at sea otter-occupied sites were no different than those from sites not occupied by sea otters (Watson and Smith 1996).

Geoduck is the most valuable shellfishery in British Columbia with a landed value of ≈$41.6 million in 2000. The Asian export (live) market averaged $23.10 per kg ex-vessel in 2000 and prices may exceed $25.00 per kg in 2001 (C. Hand, DFO, *personal communication*). In 2000, the landed value of geoduck from Haida Gwaii exceeded $23.4 million.

Geoducks are fished by divers who grasp clams' necks and unearth them with a jet from a pressurized seawater nozzle ("*stinger*"). The fishery and its management are well documented in the Integrated Fisheries Management Plan and by Campbell *et al.* (1998) and Orensanz *et al.* (2000). Therefore, a brief overview with an emphasis on the north coast only is provided here.

The fishers' organization, the Underwater Harvesters' Association [http://www.geoduck.org/], plays a key role in management, stock assessment and research. The association has two resident biologists and funds a DFO management biologist dedicated to geoduck plus one and a half DFO research positions including a GIS operator. Overall, the Association funds scientific and management work, including PSP and water quality monitoring in fishing areas, at a cost of ≈$1.3 million annually (S. Heiser, DFO, *personal communication*).

The fishery has been limited to 55 licence holders in British Columbia since 1985. Since 1989, the fishery has been managed on individual transferable quota, three-year rotation and area-licensing regulations. Each license gets one 55th of the annual quota and up to three individual quotas can be "stacked" on to, and fished from, one vessel. Currently area-licensing has 31 licences assigned to the north coast, 15 to the west coast of Vancouver Island region and nine to "inside" waters between Vancouver Island and the mainland. Within each of these regions there are three sub-regions where catching is rotated so that each sub-region is fished every third year. On the north coast, Haida Gwaii has been in the triennial fishing rotation (initiated in 1989) with the first local catch under this regime in 1991. In Haida Gwaii, the Underwater Harvesters' Association works closely with the Haida Fisheries Program and DFO in a regional partnership. For example, funds go to the Haida Fisheries Program to enable stock assessment throughout Haida Gwaii. The triennial quota for Haida Gwaii in 2000 was 2.332 million pounds (1,058.1 t), plus an additional 3,600 pounds (1.6 t) for biological samples.

The fishing amount is set (conservatively) at 1.0% of virgin biomass annually, which means that fishers' total quota is 3.0% of the biomass of the particular sub-region they are fishing. Stock assessment is by "habitat-based" diver surveys in which the biomass is estimated for each bed according to bed area, densities and average geoduck weight entered into a GIS database (Hand and Bureau 2000). As mentioned above, specific area management (Geoduck Management Area – GMA example illustrated in Figure 25) is used for geoduck stock assessment to reflect the realities of geoduck population distribution rather than relying on PFMA sub-areas. New beds are discovered each survey, which is leading to increased quotas (Hand and Bureau 2000). Approximately 30% of the estimated area of geoduck beds have been surveyed coast-wide, and for the Haida Gwaii region, the proportion assessed is highest; at ≈46 % (Hand and Bureau 2000). The map in Figure 27 illustrates the amount of stock assessment per GMA in Haida Gwaii.

Landings are provided in Table 17 showing that the catch peaked coast-wide in the late 1980s and stimulated the key management controls of 1989. Since the beginning of this fishery for the north coast in 1980, landings grew rapidly through the late 1980s to a little over half of coast-wide catch since the mid 1990s. The Haida Gwaii proportion on north coast before the three-year rotating regime was ≈30 to 40% of the north coast catch. Landings from the Gwaii Haanas area have averaged ≈65% (range 53 to 93%) of total Haida Gwaii landings since onset of the triennial rotation regime. The Underwater Harvesters' Association will, therefore, be an important participant in fishery-related management decision-making for Gwaii Haanas.

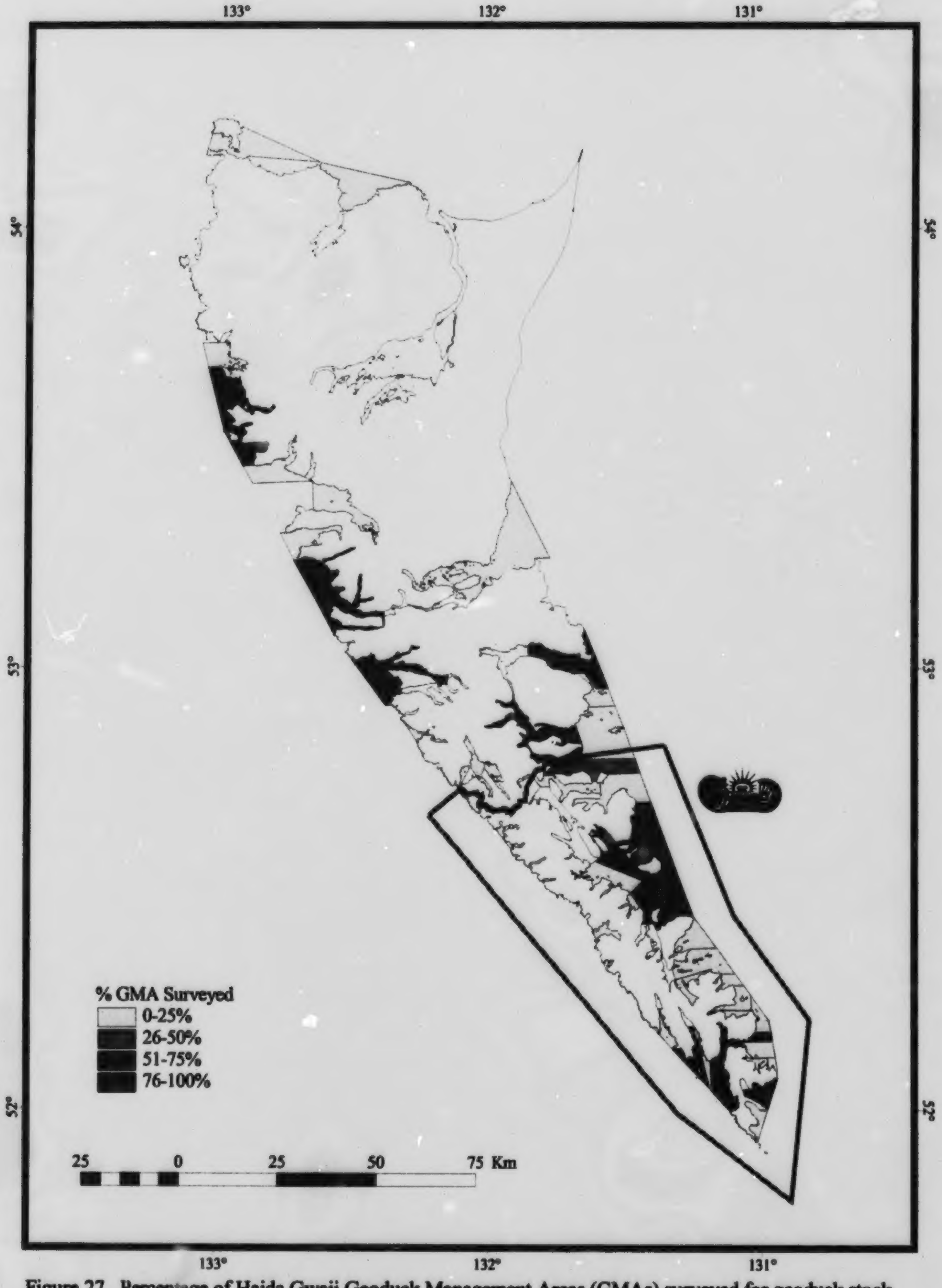
133°
132°
131°
54°
53°
52°
% GMA Surveyed
0-25%
26-50%
51-75%
76-100%
25
0
25
50
75 Km

Figure 27. Percentage of Haida Gwaii Geoduck Management Areas (GMAs) surveyed for geoduck stock assessment as of 2000 (data courtesy of M. James and G. Dovey, Underwaters Harvesters' Association; C. Hand, DFO; R. Jones and B. DeFreitas, HFP) Approximately 46 % of the estimated area of geoduck beds have been surveyed.

Table 17. Geoduck clam; total coast-wide commercial landings and proportions of landings from the north coast, Haida Gwaii and Gwaii Haanas, 1980 to 2000 (data courtesy of L. Barton, DFO).

YEAR	Total coast-wide landings in tonnes[1]	% of total Coast-wide landings reported from the North Coast[2]	% of total North Coast landings reported from Haida Gwaii[3]	% of total Haida Gwaii landings reported from Gwaii Haanas[4]
1980	2,742.4	2.6	57.7	0.0
1981	2,507.9	17.8	0.0	0.0
1982	3,020.9	11.2	0.0	0.0
1983	1,950.3	16.9	0.0	0.0
1984	3,360.9	18.8	*	*
1985	4,407.9	26.4	46.0	93.8
1986	4,369.4	31.3	41.1	66.0
1987	5,044.9	37.2	33.6	57.8
1988	4,133.5	42.8	31.5	53.0
1989	3,903.4	40.1	0.0	0.0
1990	3,957.4	40.7	0.0	0.0
1991	3,233.7	39.4	100[5]	62.6
1992	2,851.6	41.6	0.0	0.0
1993	2,421.9	42.4	0.0	0.0
1994	2,221.1	48.6	100[5]	70.0
1995	2,084.7	54.4	0.0	0.0
1996	1,841.2	56.4	0.0	0.0
1997	1,795.9	52.7	100[5]	56.9
1998	1,796.2	56.3	0.0	0.0
1999	1,796.2	54.4	0.0	0.0
2000	1,796.3	56.4	100[5]	59.9

1 from harvest log books (in round weight [shell on]) from 1980-1995; from 1996-2000 the data are combined validation and harvest logs (all log weights are now 100% validated)
2 PFMAs 1 through 10, and 101 through 110, 130 and 142 – north of Cape Caution
3 Haida Gwaii consists of PFMAs 1, 2(E + W), 101, 102, 130 and 142
4 Gwaii Haanas comprises 23 sub-areas within PFMAs 2E (sub-areas 2-8 to 2-19 = 12) and 2W (2-31 to 2-41 = 11)
5 the years in which Haida Gwaii is the location for the 3-year rotational harvest
* too few fishers landing geoducks for the data to be reportable

Dungeness Crab

Dungeness crab (*Cancer magister*) is a shallow-water, sand-dwelling, predatory species with a reasonably well known life history in the Haida Gwaii region (Boutillier *et al.* 1998 a). Crabs become sexually mature after their second year, enter the fishery at ≈3 years of age and live up to eight years. Large males can reach 210 mm carapace width and weigh over 2.0 kg. Crabs grow by discarding their old, hard shell (moulting), swelling and hardening the new, larger shell over ≈2 months. This is a time of great vulnerability to predation for Dungeness crab. After a summer moult, mature soft-shelled females copulate and store sperm until the fall when their extruded eggs are fertilized and attached to the female's abdomen. Egg-incubating females bury themselves in sand over winter to protect their broods and emerge in late winter-early spring to release free-swimming larvae that pass through six larval stages during a three to four month planktonic period. Late (megalopal) larval stages undertake vertical migrations, but spend much of their time near the surface. Larvae from different locations may travel 100s of km in currents and mix together over large offshore areas before returning inshore to settle (Crawford and Jamieson 1996). Dungeness megalopae were a dominant component of near-surface plankton in Hecate Strait in June (Burd and Jamieson 1991). After settlement, juveniles only flourish in appropriately sandy habitats.

Dungeness crab are an important prey species for sea otter in Alaska (Watson and Smith 1996). In British Columbia areas where Dungeness crab populations overlap with sea otters, anecdotal observations have not shown dramatic declines of crab populations. However, sea otter populations have not yet significantly expanded into regions where there are significant commercial crab fisheries such as Tofino on the west coast of Vancouver Island or Hecate Strait (Watson and Smith 1996). An appreciable impact of sea otters on Dungeness crab populations is, therefore, distinctly possible but awaits verification for British Columbia. Watson and Smith (1996) note the unverified sighting of sea otters, perhaps from the Barrier Islands of southeast Alaska, around northern Graham Island.

Dungeness crab are fished by baited traps or ring-nets which are deployed at 10 to 50 m depth on sandy substrates. The coast-wide landed value of Dungeness crab has exceeded $ 20 million annually for the last five years (I. Winther, DFO, *personal communication*). The average ex-vessel price in 1999 was $ 7.49 per kg. Coast-wide, the number of licences has been 222 since 1997. The coast is divided into five licence areas of which area "A" is Haida Gwaii. Since 1997, fishers have had to select one area in which to fish for a period of three years. This process was repeated at the end of 1999. Area A had 52 and 48 licences designated to fish in the three year periods beginning in 1997 and 2000 respectively.

A commercial fishery in Haida Gwaii was established by 1919 when Canada's first crab cannery began operations in Naden Harbour (Seaman 1951). By 1939 the Naden Harbour area stock was depleted and the cannery relocated to Masset in 1940 to be nearer to the McIntyre Bay and Hecate Strait stocks. After exploration and vessel development, fishing began in earnest in these areas in the late 1940s (Seaman 1951). Some Haida Gwaii catch is processed in Masset and shipped off-island live to Canadian markets.

The landings data from 1990 through 2000 reveal that the north coast and northern Haida Gwaii represent major Dungeness crab fishing areas for British Columbia (Table 18). Landings from 1950 to 1989 are illustrated in Jones and Lefeaux-Valentine (1991). The most consistent annual landings have come from the general Naden Harbour to McIntyre Bay area. Beginning in 1992, after many years of minor yields from the Dogfish Banks just east of Rose Point in Hecate Strait, very large (≈4,000 t in 1993) annual landings were reported. Annual landings from Haida Gwaii exceeded the annual coast-wide landings for the next few years, although they have been declining since the 1993 peak. The productivity of the Masset area fishery was related by Crawford and Jamieson (1996) to steady recruitment of retained larvae in Dixon Entrance by the "Rose Spit Eddy". Crawford and Jamieson could not account

Table 18. Dungeness crab; total coast-wide commercial landings and proportions of landings from the north coast and Haida Gwaii, 1990 to 2000 (data courtesy of I. Winther and L. Barton, DFO).

YEAR	Total coast-wide landings in tonnes[1]	% of total Coast-wide landings reported from the North Coast[2]	% of total North Coast landings reported from Haida Gwaii[3]
1990	1,646.2	40.9	72.0
1991	1,950.4	53.0	57.3
1992	2,650.9	63.4	69.0
1993	6,117.0	80.2	79.3
1994	4,867.0	74.0	72.0
1995	4,823.7	71.7	58.9
1996	5,144.0	76.2	44.2
1997	3,909.0	60.5	48.6
1998	2,959.0	43.6	61.0
1999	2,969.5	56.4	53.4
2000	2,931.0	38.0	47.0

1 from harvest log book data (round weight [shell on]); program in place as of 1990

2 PFMAs 1 through 10, 101 through 110, 130 and 142 - north of Cape Caution

3 Haida Gwaii consists of PFMAs 1, 2(E + W), 101, 102, 130 and 142

in their modeling for mechanisms enabling the massive recruitment to Dogfish Bank or explain why landings from McIntyre Bay remained relatively stable while those from Dogfish Bank were so high. Landings from Gwaii Haanas area are recorded for two years (1994 and 1999), but these data are confidential because too few fishers reported.

Dungeness fishery management does not rely on a total allowable catch, but on a size limit to regulate fishing levels. The fishery is considered by DFO to be "intense" and "fully utilized", although remaining sustainable. There is a legal size limit of 165 mm carapace width (including spines) - retention of females is prohibited in the commercial fishery. The size limit permits males one or two years of breeding before being fished and appears sufficient to ensure recruitment (Hankin *et al.* 1997).

There are other conservation measures such as holes in traps for escapement of undersized crabs, biodegradable rot cords or panels on traps so that lost traps will not continue to ("ghost") fish and varying seasonal (March through September) closures to prevent capture of soft-shell (newly-moulted) crab. Soft-shell and other closure areas in Haida Gwaii are illustrated in Figure 28. The bumper fishing years in Haida Gwaii initiated heavy investment in new gear with attendant concerns over too much fishing effort, and gear or catch theft. In 2000, the number of traps was limited according to vessel size coast-wide. In Haida Gwaii, the limit for vessels <13 m long is 600 and ranges to 1200 for vessels >15.8 m long. Such measures are documented in detail in the Integrated Fishery Management Plan and PSARC Fishery Update.

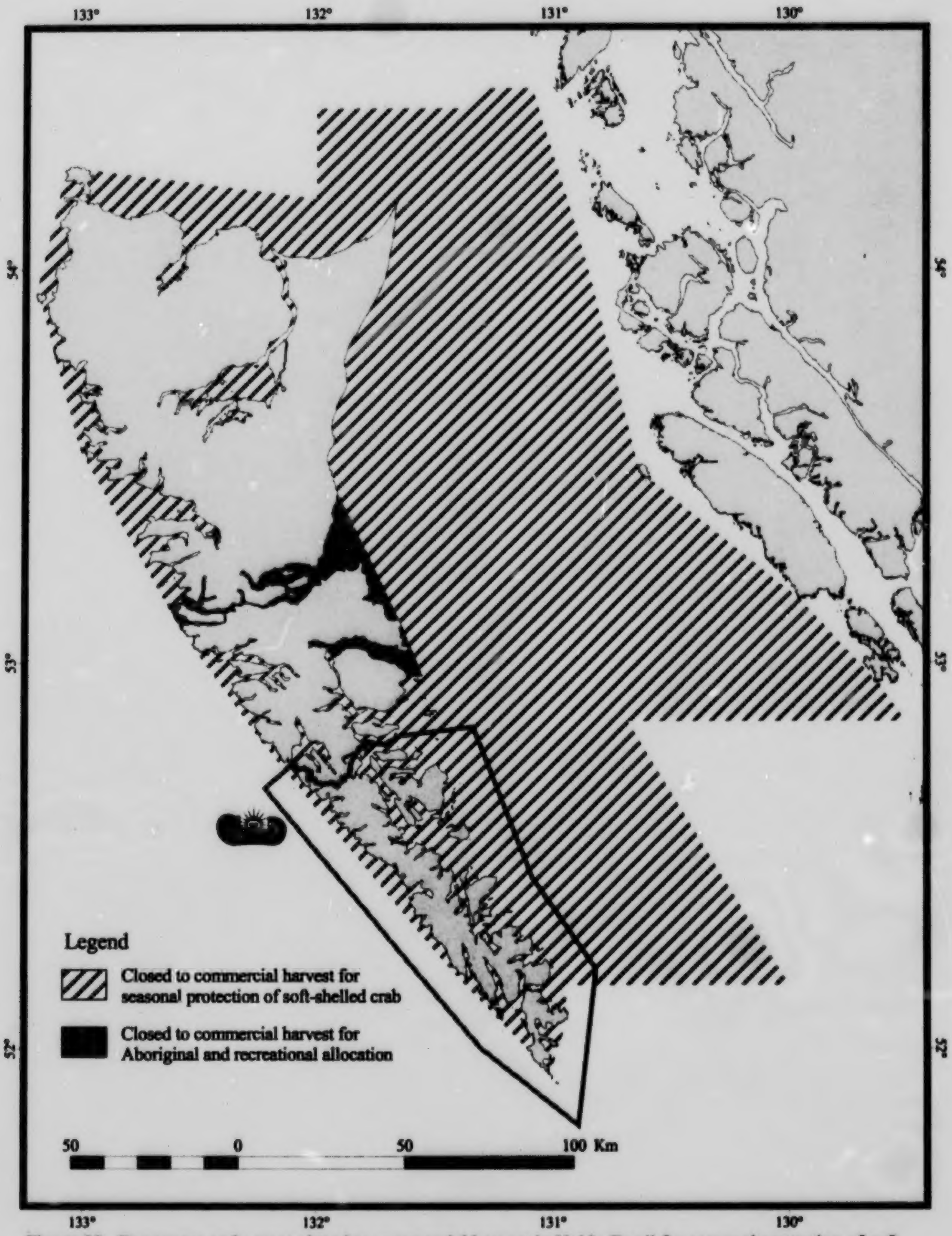
133°
132°
131°
130°
54°
54°
53°
53°
52°
52°
Legend
Closed to commercial harvest for seasonal protection of soft-shelled crab
Closed to commercial harvest for Aboriginal and recreational allocation
50
0
50
100 Km
133°
132°
131°
130°

Figure 28. Dungeness crab: areas closed to commercial harvest in Haida Gwaii for seasonal protection of soft-shelled (post-moult) crabs, and for enabling Aboriginal (Haida) and recreational allocation (Jamieson and Lessard, 2000; and courtesy of G. Jamieson, DFO).

Prawn (by trap)

The commercial shrimp and prawn species of British Columbia are all pandalids and predators/scavengers. They generally hatch in spring, spend two or three months as various larval stages in the plankton and settle in shallower water than adults. All commercial species are protandric hermaphrodites; living as males in years one and two of their lives and then as females in their final years (three and four). Individuals of some species may function as "primary females" and bypass the male phase completely. Presumably, the advantage of size is that large females can produce and brood more fertilized eggs attached to their abdomens prior to hatching. Four species vary between being pelagic or benthic depending on their daily (diurnal) cyclical behaviour. Three other species are basically benthic dwellers. The life histories of commercial shrimp species in British Columbia are reasonably well known and there is an extensive literature on their biology and fisheries (Butler 1980; Shrimp and Prawn Integrated Fishery Management Plans).

Prawn (*Pandalus platyceros*) are the largest species of commercial pandalid shrimp and they live from the intertidal to >480 m depth. Juvenile nursery areas of this benthic species are typically shallow kelp (*Agarum* spp.) forests (Marliave and Roth 1995). At age 24 to 30 months, prawns change from males into females. Prawns are fished by baited trap usually at >70 m depth over rocky substrates including habitats such as steep-sided inlets. Prawns from Haida Gwaii are mostly marketed frozen, although some are sold fresh. Coast-wide, >90% of the catch is exported to Japan frozen. Prawn is the highest value shrimp species. For example, in 1998 the price range per kg was $9.22 to $14.17 (based on size class) compared to $1.62 per kg for trawled shrimp. This is the third most valuable shellfishery coast-wide after geoduck and Dungeness crab. Coast-wide landings value peaked in 1997 at $26 million and was reduced to $18.4 million in 1998.

Prawn management is reviewed in the Prawn Integrated Fishery Management Plan and in the PSARC Fishery Update available on the prawn web site:

http://www.pac.dfo-mpo.gc.ca/ops/fm/shellfish/prawn/default.htm

Therefore, only a brief overview of prawn management is provided. The Prawn Sectoral Committee, comprising six licence holder associations, First Nations, recreational and coastal community representatives advises DFO on management.

This inshore fishery is considered by DFO to be "fully exploited", that is, all stock areas are known and likely to be fished annually. There is no total allowable catch limit. The fishery is managed by a suite of regulations including, but not limited to, the following:

- the key regulation is a fixed escapement target or "spawner index" threshold enabling closure based on the number of adult female or transitional (becoming-female) prawns captured in-season on the fishing grounds, the index (measured by charter patrol vessels of samples from the commercial catch) protects females (3^+ years old) including egg-bearers from being fished through to the end of the larval hatching period;
- limit of 253 licence holders coast-wide;
- limit of 300 traps per licence – two licences "stackable" to 500 traps per vessel;
- a legal size of 33 mm carapace length or 22 mm telson (tail) length (for product with head removed at sea); and

- trap minimum mesh size to permit escapement of undersized prawns.

A pilot area licensing program was initiated in 2000, but discontinued in 2001. The fishery usually opens in April to May, and is closed in-season when the "spawner index" declines to a pre-determined cut-off level. The shortest fishery on record was 79 days in 1999.

Coast-wide landings for prawn increased steadily since the 1980s with the north coast usually representing 20 to 30% of the catch (Table 19). Within the north coast, Haida Gwaii accounted for <10% of annual landings until 1998. Since 1996, the majority of Haida Gwaii landings have come from the Gwaii Haanas area, from which landings increased strongly - 19.8 tonnes in 1997 to 48.8 tonnes in 1999. This may relate to Gwaii Haanas being a relatively new area for the prawn fleet to fish.

Masset Inlet is the only Haida Gwaii area designated for trap fishing for the benthic humpback shrimp (*Pandalus hypsinotus*). Fishing effort in Masset Inlet is very low due to marginal prices and high logistic costs of getting live product to market.

Table 19. Prawn by trap; total coast-wide commercial landings and proportions of landings from the north coast, Haida Gwaii and Gwaii Haanas, 1984 to 2000 (data courtesy of L. Barton, DFO).

YEAR	Total coast-wide landings in tonnes[1]	% of total Coast-wide landings reported from the North Coast[2]	% of total North Coast landings reported from Haida Gwaii[3]	% of total Haida Gwaii landings reported from Gwaii Haanas[4]
1984	432.0	22.8	2.5	*
1985	463.1	23.7	3.9	90.6
1986	465.1	22.9	1.1	*
1987	547.1	27.2	2.5	30.0
1988	620.9	33.4	0.4	14.5
1989	744.9	25.4	< 0.1	*
1990	742.1	16.9	0.2	*
1991	882.2	17.5	*	*
1992	1,132.9	23.5	3.2	*
1993	1,120.6	25.7	0.9	*
1994	1,251.2	30.7	0.0	0.0
1995	1,329.2	32.3	0.9	*
1996	1,714.4	36.5	6.2	80.3
1997	1,785.0	20.4	8.6	62.9
1998	1,733.3	20.7	18.9	50.9
1999	1,459.5	27.0	19.5	63.4
2000	1,715.6	25.7	16.1	44.1

1 from harvest log books (round weight [shell on])
2 PFMAs 1 through 10, 101 through 110, 130 and 142 - north of Cape Caution
3 Haida Gwaii consists of PFMAs 1, 2(E + W), 101, 102, 130 and 142
4 Gwaii Haanas comprises 23 sub-areas within PFMAs 2E (sub-areas 2-8 to 2-19 = 12) and 2W (2-31 to 2-41 = 11)
* too few fishers landing prawn for the data to be reportable

Red Sea Urchin

Red sea urchin (*Strongylocentrotus franciscanus*) is a dominant and ubiquitous invertebrate on shallow subtidal rocky shores throughout Haida Gwaii (Jamieson and Campbell 1995). It is present in large numbers and exerts conspicuous impacts by denuding rocky substrates through grazing on attached (and drift) seaweeds and kelp. Visible impacts include decreasing kelp forest canopy area and creating red sea urchin-dominated "barrens". Barrens occur as a light-coloured band of encrusting coralline algae on rocks denuded of fleshy algae (and species of sessile invertebrates) immediately seaward of intact kelp forests (Steneck and Dethier 1994). For example, ≈50% of rocky coastline of Gwaii Haanas has kelp forest and half of that is bordered to seaward by barrens (Sloan and Bartier 2000). A distinct possibility is that the extirpation of sea otters (perhaps by the mid to late 19th century) likely led to increased populations of red sea urchin with attendant kelp deforestation and expansion of barrens.

The ecology of red sea urchins is reasonably well known because the species is so prominently associated with the loss or diminishment of kelp forests from Alaska to southern California (Foster and Schiel 1985; Campbell and Harbo 1991; Estes and Duggins 1995; Schroeter *et al.* 1996; Tegner *et al.* 1997; Dayton *et al.* 1998). Sexes are separate and gametes are broadcast into the water column for external fertilization in spring through summer. Shell ("test") diameter for sexually mature individuals starts at ≈50 mm diameter, attained at ≈4 years of age. Larval duration is up to ≈65 days in the plankton. The young tend to settle near adults and subsequently migrate to reside under the adults' spine canopies for protection. Red sea urchins tend to form feeding fronts seaward along kelp forests in the shallow subtidal from 0 to 4 m below the extreme low tide level (Jamieson and Campbell 1995). Their upper distribution limit is set by their avoidance of wave action and low tide aerial exposure. Sea otters have reduced red sea urchin populations from Alaska to California to the extent that some red sea urchin fisheries are excluded in areas of established sea otter populations (Watson and Smith 1996).

Red sea urchins are collected by hand-rake by divers. The product is their roe, sold fresh mostly to Japan. Prices vary according to roe size, colour and texture. The fishery, therefore, is associated with the seasonality of roe quality which is itself linked to sea urchin feeding opportunities dependent on the seasonal abundance of algae feed-stocks (Conand and Sloan 1989).

The commercial north coast red sea urchin fishery began in 1984, but landings did not become appreciable until 1989 (Table 20). Coast-wide, the north coast has dominated landings since 1991. Within the north coast, Haida Gwaii has averaged ≈16 % of annual landings since 1994. The first Haida Gwaii landings (2.2 tonnes in 1984) came from PFMA 1 and none were again recorded from Haida Gwaii until 1989. By 1997, Haida Gwaii landings were recorded from PFMAs 1, 2 (E and W) and 101. The Gwaii Haanas area has accounted for ≈50% of annual Haida Gwaii landings since 1992. This means that the industry association (Pacific Urchin Harvesters' Association) will be an important stakeholder in forthcoming fisheries management consultations concerning Gwaii Haanas.

Management is considered "*conservative*" by DFO because only 2 to 3 % of the estimated biomass is fished. Not all areas have, however, been surveyed for biomass – another good reason for cautious management. The fishery is well documented (Campbell 1998; Campbell *et al.* 1999; red sea urchin Integrated Fisheries

Table 20. Red sea urchin; total coast-wide commercial landings with proportions of landings from the north coast, Haida Gwaii and Gwaii Haanas, 1989 to 2000 (data courtesy of L. Barton, DFO).

YEAR	Coast-wide total landings in tonnes[1]	% of total coast-wide landings reported from the North Coast[2]	% of total North Coast landings reported from Haida Gwaii[3]	% of total Haida Gwaii landings reported from Gwaii Haanas[4]
1989	2,004.4	36.9	21.4	*
1990	2,439.2	48.8	*	*
1991	6,426.3	81.0	6.7	*
1992	12,477.7	89.7	10.4	57.0
1993	6,105.2	85.9	6.3	61.2
1994	5,958.7	85.2	15.6	43.2
1995	6,805.7	84.3	16.6	43.6
1996	6,465.2	83.8	16.0	50.7
1997	5,566.9	79.4	18.9	46.1
1998	6,086.7	82.5	15.4	54.3
1999	5,392.4	81.8	16.2	46.0
2000	5,286.4	85.5	17.9	39.6

1 landings (intact round weight) are from harvest logs from 1989 through 1996; from 1997 to 2000 data are from combined harvest logs and validation logs (all weights are 100% validated)
2 PFMAs 1 through 10, 101 through 110, 130 and 142 - north of Cape Caution
3 Haida Gwaii consists of PFMAs 1, 2(E + W),102, 130 and 142
4 Gwaii Haanas comprises 23 sub-areas within PFMAs 2E (sub-areas 2-8 to 2-19 = 12) and 2W (2-31 to 2-41 = 11)
* data are confidential because of too few fishers reported catch

Management Plan). The Pacific Urchin Harvesters' Association works closely with DFO in stock assessment and research. Current management regulations for the north coast 2000-2001 season include, but are not limited to:

- a precautionary total allowable catch of 4,024 t based on stock assessments;
- area licences limited to 91 out of a coast-wide total of 110;
- an individual licence quota of a 110th of the total allowable catch; and
- a minimum size limit of 90 mm test diameter.

In Haida Gwaii, the Pacific Urchin Harvesters' Association works closely with the HFP and DFO in stock assessment and research. The HFP is funded by this partnership to support stock assessment and research. Culturally, red sea urchin is an important fishery for the Haida and there are small areas closed to commercial fishing throughout the archipelago to enable undisturbed Haida food fishing. These and green sea urchin closures in Haida Gwaii are illustrated in Figure 29.

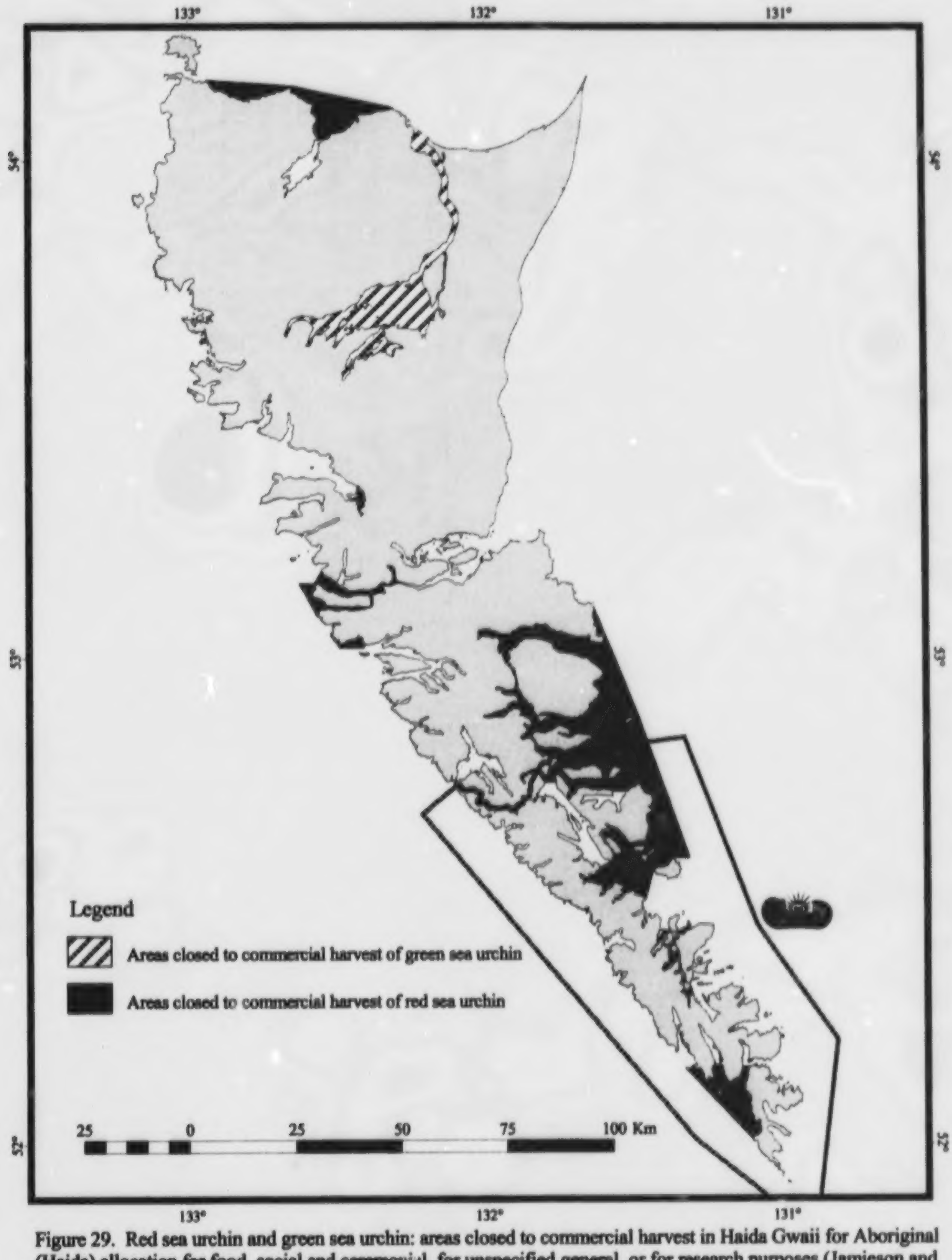
133°
132°
131°
54°
53°
52°
Legend
▨ Areas closed to commercial harvest of green sea urchin
■ Areas closed to commercial harvest of red sea urchin
25
0
25
50
75
100 Km
133°
132°
131°

Figure 29. Red sea urchin and green sea urchin: areas closed to commercial harvest in Haida Gwaii for Aboriginal (Haida) allocation for food, social and ceremonial, for unspecified general, or for research purposes (Jamieson and Lessard, 2000; and courtesy of G. Jamieson, DFO).

Northern Abalone

Northern abalone (*Haliotis kamtschatkana*) presents a special management challenge for Gwaii Haanas for cultural, political and technical reasons. The following attributes of northern abalone make the species very topical to the future management of Gwaii Haanas:

- northern abalone was, in 1990, the first fishery in Pacific Canada to be closed by DFO to all fishers (First Nations, commercial, recreational) and it remains closed due to chronically low stocks coast-wide and an appreciable poaching problem because of its high value on the black market (Jamieson 1999; Campbell 2000);
- marine area protection may be particularly suitable for northern abalone well-being because of their life history characteristics (sedentary, site-specific, limited larval dispersal) render the species both amenable to zoning issues such as fishing refugia, and highly vulnerable to over-fishing (Jamieson 2000; Sloan and Bartier 2000);
- northern abalone is the subject of DFO's Abalone Stock Rebuilding Strategy launched in 1999;
- northern abalone was the first Canadian marine invertebrate to be designated, in April, 1999, by COSEWIC as *"threatened"* [i.e., *"likely to become endangered if limiting factors are not reversed"*] – this status will likely trigger species-at-risk regulations under Environment Canada's proposed *Species at Risk Act*;
- with species-at-risk funding from EC in 2000, a co-operative (Parks Canada, DFO, Haida Fisheries Program, Laskeek Bay Conservation Society) Haida Gwaii study to establish two northern abalone stewardship locations was initiated (Figure 30);
- there is inherent "ecosystem restoration" conflict between rebuilding northern abalone populations and the likely eventual return of one of their predators, the sea otter (Watson 2000), to Haida Gwaii;
- the northern abalone closure represents a food-gathering and cultural loss to the Haida Nation (Richardson and Green 1989; Neis *et al.* 2000) whose members were not active in the commercial fishery that initiated the stock collapse; and
- as northern abalone is a kelp forest-associated species, its well-being in Gwaii Haanas will be directly affected by any eventual return of an important predator, the sea otter.

The life history of northern abalone is reviewed in detail by Sloan and Breen (1988), so only a brief overview is provided here. It is a small, slow-growing species whose characteristics vary according to the type of wave exposure regime and kelp forest habitat occupied. Many generalizations on their life history are inferred from those of other abalone species as the biology of this group is relatively uniform. Larval dispersal is likely limited as the non-feeding larvae may spend <10 days in the plankton. Adults are sedentary herbivores of drift and attached seaweeds and do not range widely. Northern abalone populations, therefore, fit well the model of being composed of discrete sub-populations distributed according to appropriate rocky habitat type and linked by (limited) larval dispersal. Although very little is known about the early life history of northern abalone, it is reasonable to speculate that sustainable populations are those forming sufficiently dense clumps for fertilization of synchronously-spawned gametes and for successful settlement of larvae nearby.

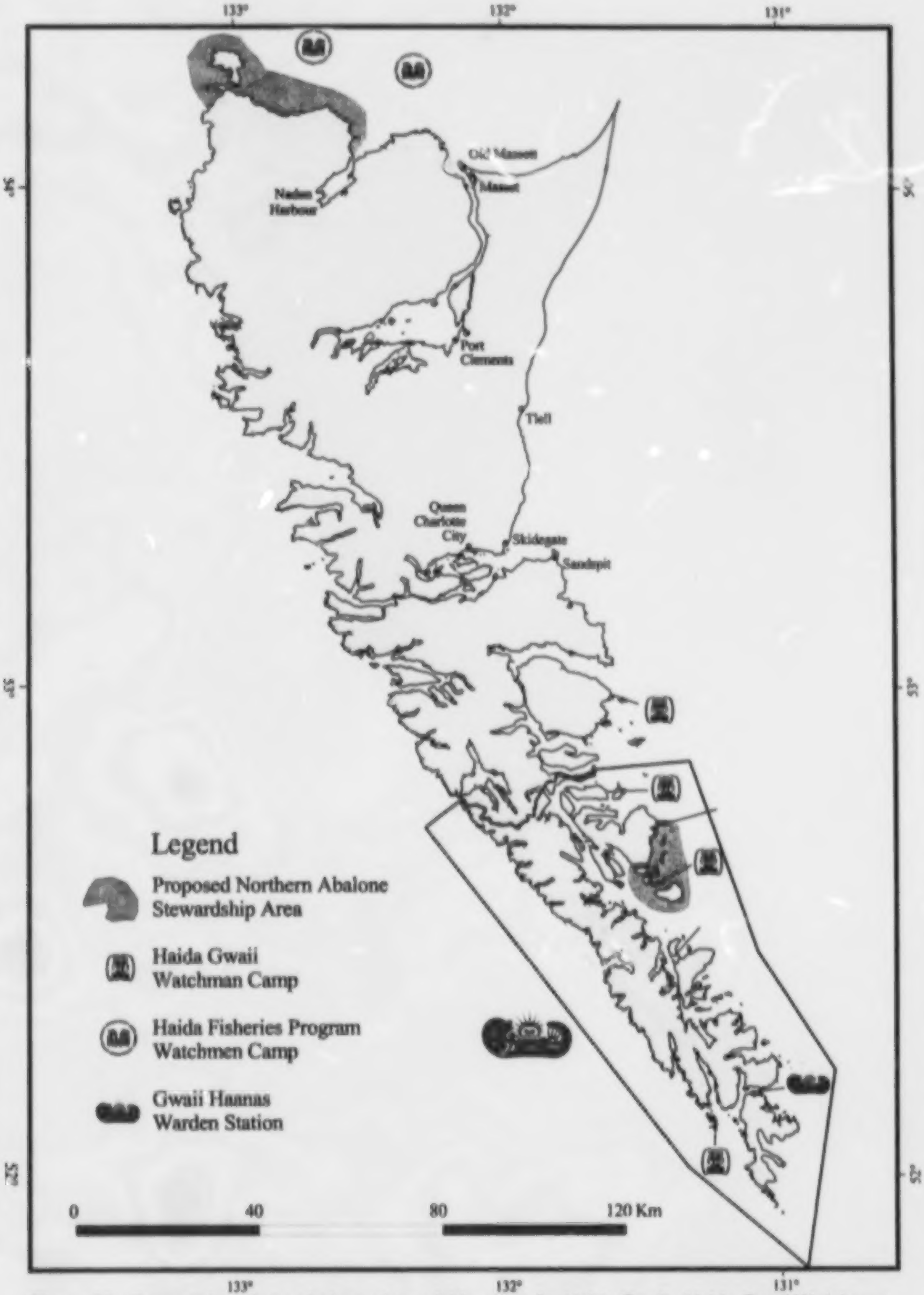
133°
132°
131°
54°
53°
52°
Old Massett
Masset
Naden Harbour
Port Clements
Tlell
Queen Charlotte City
Skidegate
Sandspit
Legend
Proposed Northern Abalone Stewardship Area
Haida Gwaii Watchman Camp
Haida Fisheries Program Watchmen Camp
Gwaii Haanas Warden Station
0
40
80
120 Km

Figure 30. Proposed northern abalone stewardship areas for Haida Gwaii. Haida Gwaii Watchmen camps are operated by the Council of the Haida Nation from approximately May to September to protect the natural and cultural heritage, provide visitor interpretation and enable fisheries surveillance at historical Haida village sites and their nearby areas. The northern Watchmen camps are managed by the Haida Fisheries Program out of Old Massett village and the southern Watchmen camps are managed by the Watchmen Program out of Skidegate village.

At the end of the 1990 season, northern abalone fishing was closed to all fishers coast-wide. At that time, its ex-vessel price was the highest of any shellfish species at ≈$26.90 per kg. In Haida Gwaii, the commercial abalone fishery had a long history (Sloan and Breen 1988). There were a number of small Japanese-run drying and canning operations in the early 1900s to ≈1913 (Dalzell 1973; Morton 1992). There were drying operations on Faraday, Murcheson and Ramsay Islands and canneries at Rose Harbour and Jedway Bay. A diving fishery did not begin in the north coast until the late 1950s.

Haida Gwaii landings records from 1977 to 1990, are listed in Table 21. Generally, most landings came from southern Haida Gwaii, particularly PFMA 2E. Landings peaked in 1977, and, after another high year in 1978, quotas were introduced (Sloan and Breen 1988). Table 22 lists regional representation of landings from 1983 to 1990. The north coast averaged ≈76 % of annual coast-wide landings. In most years, Haida Gwaii dominated total north coast landings and within Haida Gwaii, Gwaii Haanas area dominated landings from 1987 onward. Overall, the Gwaii Haanas area was a historically important fishing area for northern abalone in British Columbia. The northern abalone fishery also went "boom-to-bust" in southeast Alaska and was closed in 1995 (Woodby *et al.* 2000). This tendency of over-fishing followed by stock declines is mirrored by other abalone species fisheries in California (Shepherd *et al.* 1992), with the white abalone (*Haliotis sorenseni*) on the brink of extinction (Davis *et al.* 1998).

There now is political will among federal agencies towards cooperative regional programs to improve the status of northern abalone populations and their stewardship. Specifically, there is a confluence of interests

Table 21. Northern abalone; total commercial landings and proportions of landings according to PFMA from Haida Gwaii, 1977 to 1990 (data from Harbo 1997).

YEAR	Total Haida Gwaii landings in tonnes[1]	% of Haida Gwaii landings according to PFMA		
		1	2E	2W
1977	318.2	14.3	81.5	4.2
1978	128.8	9.8	78.8	11.4
1979	37.8	7.0	78.0	15.0
1980	23.0	13.9	70.0	16.1
1981	29.3	6.5	72.7	20.8
1982	26.8	48.5	50.8	0.7
1983	32.4	37.3	62.7	0
1984	29.1	48.8	48.2	3.0
1985	14.0	68.6	31.4	0
1986	23.8	64.3	26.9	8.8
1987	21.9	20.6	65.3	14.1
1988	28.5	28.0	67.0	5.0
1989	19.7	26.9	56.8	16.3
1990	18.7	31.5	65.3	3.2

1 landings (round weight [shell on]) from harvest logs

between the DFO stock rebuilding strategy and an Environment Canada-funded species-at-risk initiative. Contributing to this will be the database on northern abalone areas in Haida Gwaii and Gwaii Haanas from DFO stock surveys (Sloan and Breen 1988; Thomas *et al.* 1992; Winther *et al.* 1995; Campbell 1996). Also contributing will be Gwaii Haanas' shoreline database (Harper *et al.* 1994) and the extensive field survey knowledge of the HFP dive team. These attributes underpin the opportunity to use Gwaii Haanas as a northern abalone benchmark site for cooperative, long-term, science-based management.

Horse Clams

Two species of horse clam (*Tresus capax* and *T. nuttallii*) are found in the lower intertidal and shallow subtidal sand and gravel beaches of moderate to low wave exposure in Haida Gwaii. Horse clam biology and fisheries in British Columbia was reviewed by Lauzier *et al.*(1998). Horse clam are readily eaten by sea otters, but there are no data on population-level impacts of this predation (Watson and Smith 1996).

There is no directed fishery targeting horse clam. Coast-wide, landings are small due to low price and reported as incidental bycatch to the geoduck fishery as only those licensed for geoduck can take horse clam. In 1999, fishers received an average of ≈$1.90 per kg for horse clam compared to ≈$18.70 for geoduck. In Haida Gwaii, landings have been low and sporadic; between 1979 and 1998, 12.4 t were landed in four seasons from PFMA 2E. There is a habitat impact concern with fishing as horse clam often live in eelgrass (*Zostera marina*) meadows in the lower intertidal and shallow subtidal zones.

Intertidal Clams

The butter clam (*Saxidomus gigantea*) and the littleneck clam (*Protothaca staminea*) are found in the mid to lower intertidal sand

Table 22. Northern abalone; total coast-wide commercial landings and proportions of landings from the north coast, Haida Gwaii and Gwaii Haanas, 1983 to 1990 (data courtesy of L. Lacko, DFO).

YEAR	Total coast-wide landings in tonnes[1]	% of total Coast-wide landings reported from the North Coast[2]	% of total North Coast landings reported from Haida Gwaii[3]	% of total Haida Gwaii landings reported from Gwaii Haanas[4]
1983	56.3	81.4	74.6	47.6
1984	56.5	64.5	40.7	57.3
1985	42.2	75.9	51.7	*
1986	51.5	82.2	66.0	37.1
1987	48.7	80.7	62.6	81.9
1988	48.9	91.4	66.6	72.0
1989	47.8	68.3	68.9	*
1990	50.0	67.1	70.9	71.7

1 from sales slip data of round weight [shell on]
2 inshore PFMAs 1 through 10 – all north of Cape Caution
3 Haida Gwaii consists of all of inshore PFMAs 1 and 2(E + W)
4 Gwaii Haanas comprises 23 sub-areas within PFMAs 2E (sub-areas 2-8 to 2-19 = 12) and 2W (2-31 to 2-41 = 11)
* too few fishers landing catch for the data to be reportable

and gravel shores of moderate to low wave exposure in Haida Gwaii. The life history of these species is reasonably well known (Gillespie and Bourne 1998). Sea otters can prey heavily on them in Alaska and British Columbia. On the northwest coast of Vancouver Island, butter clam biomass was ≈12-fold less in the intertidal and ≈20-fold less in the subtidal at sites occupied by sea otters compared to sites without sea otters (Watson and Smith 1996).

Early commercial fisheries in Haida Gwaii saw development of a cannery for these species near Burnaby Narrows in Bag Harbour from 1908 to 1913 (Morton 1992). Low prices and the blanket north coast regional closure in effect since 1963 due to the chronic paralytic shellfish poison threat to public health and safety have discouraged commercial fishing in Haida Gwaii and there have been no commercial landings since the 1980s.

Coast-wide, intertidal clam fisheries have occurred since the early 1900s. Fisheries and life history information on intertidal clams are summarized in the intertidal clam fishery update and management plan. The intertidal clam fishery has become dominated by landings of the introduced Manila clam (*Venerupis philippinarum*). In 1996, Manila clam accounted for 77% of all intertidal clam landings in British Columbia (Gillespie and Bourne 1998). At present, Manila clam does not occur further north than the southern end of Laredo Channel (Gillespie and Bourne 1998). An attempt was made to introduce Manila clams to Haida Gwaii as will be discussed below in the section on introduced species.

Octopus

Giant Pacific octopus (*Enteroctopus dofleini*) are active predators of benthic invertebrates such as crab and occur over rocky bottom areas coast-wide. It is the world's largest species with males reaching up to 25 kg. Gillespie *et al.* (1998) report moderate progress on understanding this species' life history in British Columbia waters since the review of Hartwick (1983). Harbour seal (*Phoca vitulina*) and sea otter eat octopus, but nothing is known about population-level impacts of sea otter predation on octopus populations (Watson and Smith 1996).

Octopus has been reported as landed by diver, by a directed trap fishery (discontinued in 1999) and as "bycatch" (incidentally caught while targeting other species) in crustacean trap and finfish bottom trawl fisheries. The product used to be sold mostly for bait, but seafood markets have recently developed. Since 1999, Dungeness crab and prawn trap fishers can retain octopus bycatch if they have a special designation on their licence requiring them to complete an octopus biological data logbook.

Total Haida Gwaii landings by all gear types, for the 16 years from 1984 to 1999, were ≈20 t (reported in 9 years) from PFMA 1 and ≈47 t (reported in 15 years) from PFMA 2E. Total Haida Gwaii landings of ≈6 t for 1981 through 1983 were reported in Jones and Lefeaux-Valentine (1991).

Offshore Neon Flying Squid

Neon flying squid (*Ommastrephes bartrami*) is an oceanic, offshore predatory species that enters offshore British Columbia waters in summertime intrusions of warm (15 to 20 °C) seawater. In some years, typically warm water or El Niño years, flying squid may come as far inshore as Gwaii Haanas' proposed western seaward boundary. Basic life history knowledge remains rudimentary in British Columbia. Since the mid 1990s, exploratory fishing by jigging have occurred offshore of Gwaii Haanas in PFMAs 130 and 142 (Gillespie 1997 and *personal communication*). Flying squid is currently managed as a developing fishery under an experimental management plan.

Inshore Opal Squid and Continental Shelf Red Squid

There is little new to report on these species since Jones and Lefeaux-Valentine (1991). Basic life history of these species in British Columbia has received little attention since Bernard (1980). All squids are active pelagic predators, usually living no longer that two years and only spawning once.

Small amounts of opal squid (*Loligo opalescens*) have been taken inshore by trawl or seine intermittently. For example, a mean of less than one tonne was taken annually between 1984 to 1989 (Jones and Lefeaux-Valentine 1991). Separate landings data for this species are not now maintained for Haida Gwaii.

Red squid (*Berryteuthis magister*) continue to be taken as bycatch in various Hecate Strait and Dixon Entrance bottom trawl fisheries. Landings data are mixed with those from other squid species. Basic red squid life history research has not been done in British Columbia.

Shrimp (by trawl)

The shrimp species fished in Haida Gwaii by otter or beam trawl are mostly humpback (*Pandalus hypsinotus*), with lesser amounts of smooth pink (*P. jordani*) and spiny pink (*P. borealis*). These species' biology is reviewed in Butler (1980) and in the PSARC Fishery Update and Integrated Fishery Management Plan.

Historic Haida Gwaii shrimp-by-trawl landings have been sporadic and low (Table 23). Virtually no landings have been reported from PFMA 1 since 1997. From PFMA 2, the highest recorded landings of 18.5 t (in 1998/99 – landed during April 01 to March 31) were reported from nearby Gwaii Haanas. DFO adopted a precautionary approach, so that in 1997, a catch ceiling of 10 t was set for the combined inshore PFMA 2 (E + W) and offshore PFMAs 102 and 143. This was increased to 25 t in 1998. Thereafter, PFMA 2 was split off with a ceiling of 10 t, and 25 t were allocated to PFMAs 102 and 142.

Table 23. Shrimp by trawl; average annual commercial landings from Haida Gwaii, 1982 to 2000 (data courtesy of L. Convey, DFO).

PFMA	Number of years where data are reportable[3]	Annual landings (tonnes)	
		Average	Range
1[1]	17	3.9	0-22.5
2[2]	11	4.4	0-18.5

[1] inshore PFMA 1 + offshore PFMA 101

[2] inshore PFMA 2 (E + W) + offshore PFMA 102

[3] some years had too few fishers reporting for the data to be reportable

King Crab

Red king crab (*Paralithodes camtschatica*) is a large predatory species found down to depths exceeding 300 m. In spring, red king crab move into ≈15 m depth to moult and mate in inshore (inlet) waters throughout the northern British Columbia coast (Jamieson and Sloan 1985). Red king crab has been the target of a large fishery in Alaska, but is only sporadically fished in (northern) British Columbia. The biology of populations is little known from British Columbia waters.

Landings of king crab from PFMA 1 occurred in three years between 1989 and 1995 and for PFMA 2 (2E + 2W) twice between 1988 and 1996. Total landings from all areas in all years were <11 t. These were exploratory fisheries with no further activity after 1996.

Goose Barnacle

Goose barnacle (*Pollicipes polymerus*) attach themselves by flexible stalks in dense clusters on mid rocky intertidal shores exposed to high wave action. Life history of goose barnacles in British Columbia has been recently reviewed by Lauzier (1999 a).

Landings for goose barnacle are recorded once from PFMA 1 (1994) and three times in PFMA 2 (2E + 2W) between 1988 and 1993. Total landings from all areas in all years were <10 t. As with king crab, these were exploratory fisheries and there has been no further fishing since 1994. The fishery is presently closed in British Columbia.

Tanner Crabs

Tanner crab (*Chionoecetes tanneri* and *C. angulatus*) are deep-water continental shelf and slope predatory species. There are established fisheries for *Chionoecetes* species in Alaska and in eastern Canada where they are called "snow" crab. The life history of Tanner crab is little known from British Columbia waters.

Fisheries and Oceans Canada began investigating the commercial potential of Tanner crab (*Chionoecetes tanneri* and *C. angulatus*) with a literature review and development of an exploratory assessment program in 1997. Assessment and development of a possible future commercial fishery on these species is occurring under the science advisory framework (Perry *et al.* 1999) for new and developing invertebrate fisheries (J. Boutillier and G. Workman, DFO, *personal communications*). Two sources of data are required to assess Tanner crab; area-swept trawl density data collected by DFO and distributional trap Catch Per Unit Effort (CPUE) data collected by industry participants. Biomass estimates are calculated using the trawl density data (crabs per km^2) and habitat area (km^2) estimated using a GIS. These estimates are then adjusted using the CPUE for each area. Two area-swept trawl surveys have been completed; central west coast of Vancouver Island (Nootka region) in 1999 and Queen Charlotte Sound and West Coast of Haida Gwaii in 2000. Approximately 40% of the coast has been covered by the industry trap survey. At present, DFO is working with industry to complete the trap survey. Where the trap survey has been completed, DFO is initiating an experimental fishery to assess population responses to fishing and validate biomass estimates (Workman *et al.* 2000). The current experimental fishery is operating off the northwest coast of Vancouver Island in PFMA 125.

In summer 2000, exploratory sounding, trawling and trapping was undertaken in the deep continental slope waters off Queen Charlotte Sound and the West Coast of Haida Gwaii. Survey objectives were to identify potential Tanner crab habitat, conduct experimental trawling and trapping for distribution and abundance data and collect general species biodiversity data from these unfished depths. Commercial fishing has taken place in these areas previously, but at much shallower depths. Trawling and trapping (at 500 to 1900 m depth – Figure 31) was executed with a large shrimp trawl (fitted with a small-mesh cod-end liner to retain animals to 10 mm length) or with baited conical top-loading traps. In traps, crabs dominated the catch with fewer than a dozen species encountered as by-catch, conversely, in trawls >140 taxa were captured in association with crabs. Each set's catch was sorted to species and weighed, enabling the identification of all animals. For all species of crab, size, weight, maturity state, and shell condition were recorded for use in stock assessments and in life history studies. Deep sampling yielded increased catches of *C. angulatus* and two other little known deep water crab species, *Paralomus verrilli*

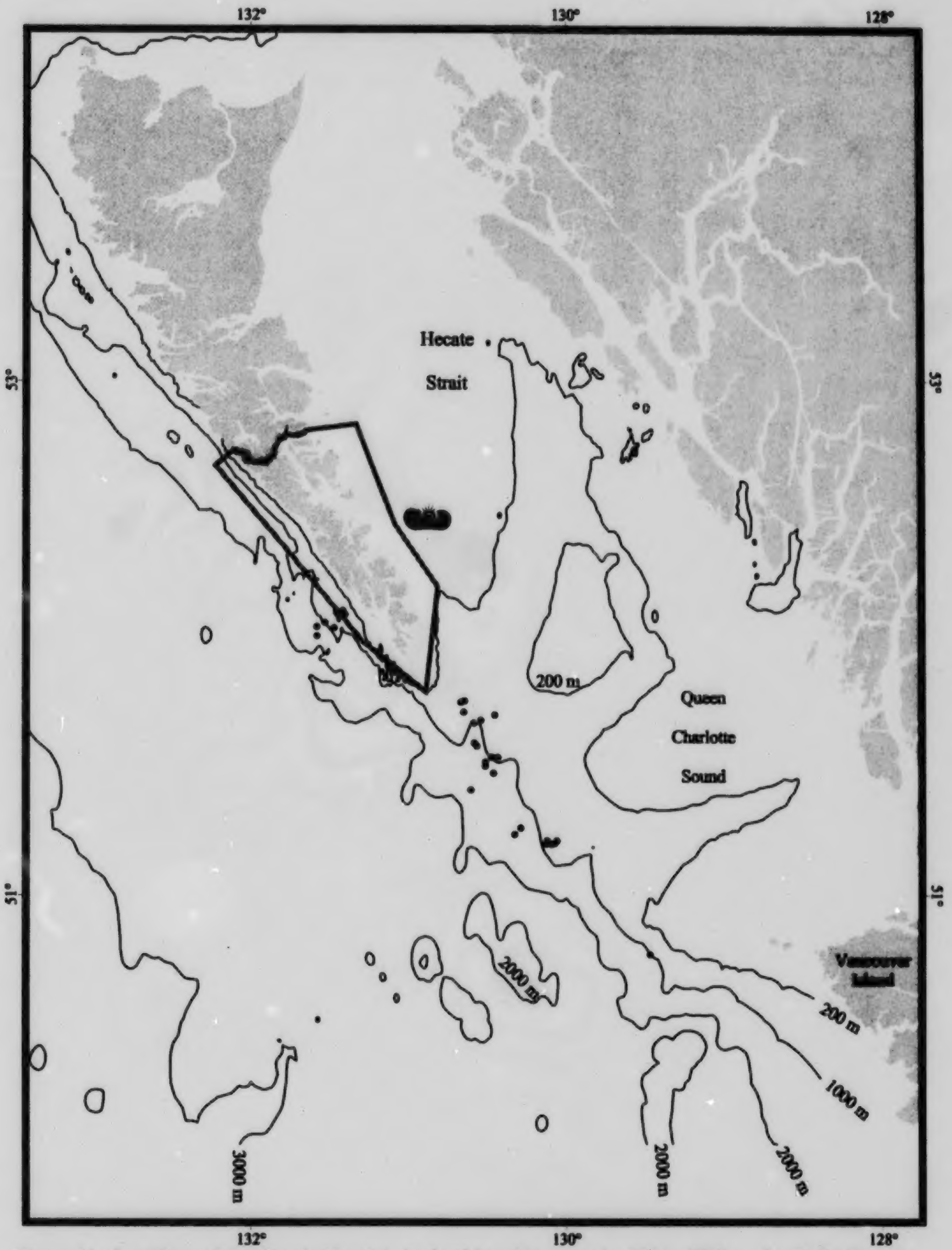
132°
130°
128°
53°
51°
Hecate
Strait
200 m
Queen
Charlotte
Sound
Vancouver
Island
2000 m
200 m
1000 m
3000 m
2000 m
2000 m

Figure 31. Locations of trawling (mid-points for hauls) and trapping (at 500 to 1900 m. depth) for Tanner crabs off the west coast of Haida Gwaii and in Queen Charlotte Sound, summer 2000 (courtesy of G. Workman and J. Boutillier, DFO).

and *P. multispina*. Sufficient numbers of *P. verrilli* and *P. multispina* were caught to provide the first basic population data ever collected for these species in British Columbia. At depths >1500m *P. verilli* dominated, from 1000 to 1500 m depth *C. angulatus* and *P. multispina* dominated, and at depths <1000 m *C. tanneri* and *P. multispina* were most abundant. Tanner crab (*C. tanneri*) were less abundant off Haida Gwaii than off the West Coast of Vancouver Island. Significant quantities of *C. angulatus*, however, occupy the deeper depths off Haida Gwaii. The preliminary invertebrate species biodiversity data (≈70 taxa) were contributed to the database in Appendix D and the full cruise results will be reported by Workman *et al.* (2000, *in preparation*).

Green Sea Urchin

Green sea urchin (*Strongylocentrotus droebachiensis*) is a circumpolar, arctic-boreal species whose life history is particularly well studied in the north Atlantic. It is a smaller species than the red sea urchin, but is also a herbivorous grazer on attached and drift seaweed. Fishing is by divers and the commercial product is sea urchin roe. As with red sea urchin, sea otters are known to reduce green sea urchin populations in Alaska and British Columbia (Watson and Smith 1996).

The fishery in Haida Gwaii has been small with exploratory landings from PFMA 1 in 1989 and 1990 and PFMA 2E in 1990 only. Combined north coast (PFMAs 1 to 10) landings between 1987 to 2000 have not exceeded 150 t. Coast-wide, the fishery is dominated by south coast landings (Perry and Waddell 1999). All of Masset Inlet (PFMA 1-6) is closed to commercial fishing as an allocation to Haida food fishing (Figure 29).

Sea Cucumber

The red sea cucumber (*Parastichopus californicus*) is a large species (to 45 cm length) found from the lowest intertidal zone to over 100 m depth on a wide range of rocky to sandy habitats of moderate to low exposure. It uses a ring of cauliflower-like tentacles at the anterior end of its cucumber-shaped body to mop up deposited material. Sea cucumbers digest the organic components of ingested sediments and void the indigestible components. The life history of this species is poorly known (Boutillier *et al.* 1998).

Commercial fishers dive to collect sea cucumbers by hand. Catch weight is reported "split" (de-watered and gutted). Products are boiled body walls for export to Asia and muscle strips from inside the body walls for both export and domestic consumption. The management of this fishery is covered in detail the Integrated Fishery Management Plan, so only a Haida Gwaii area overview is provided.

The first landings of sea cucumber from Haida Gwaii started in 1987 from PFMA 2E and 2W. From 1987 through 1995, PFMA 2W reported total landings of three t split weight from two years of fishing whereas PFMA 2E averaged 42.5 t annually from nine years of fishing. Since 1996, Haida Gwaii has been closed to fishing due, in part, to low market value and processing logistics rendering this area economically marginal. The other reason is that sea cucumber is the target of the first shellfish adaptive management experiment in British Columbia as described in the Integrated Fishery Management Plan. Adaptive management is discussed below. The Haida Gwaii closure is part of such an experiment, now halfway through its 10-year life. It is possible that the fishery could be reopened for Haida Gwaii at some time after this experiment.

SHELLFISHERIES MANAGEMENT SUMMARY

Shellfisheries management is a moving target involving multiple species with criteria changing according to fluctuating stock status and new technical information. Nonetheless, an overview of the basics is provided here. The major shellfisheries occur mostly inshore with the exception of Dungeness crab in the northwestern region of Hecate Strait (Table 24). Among those with offshore landings (Dungeness crab and red sea urchin), almost 100% of landings are in the east and northern offshore (PFMAs 101 and 102) compared to the west and southern offshore (PFMAs 130 and 142).

With so much shellfisheries information, a quick management overview is warranted. Summarized in Table 25 are the management criteria for the major shellfisheries of Haida Gwaii. The main points are as follows:

- each fishery is unique in the blend of biological and management criteria used;
- DFO attempts to provide a scientific basis for all management advice; and
- not all fisheries depend on stock assessments for their management.

The species' life histories and the human understanding thereof dictate the management criteria and will influence future spatial management decisions. For Gwaii Haanas, management of the most important fisheries is based on total allowable catches arising from stock assessment (geoduck and red sea urchin) and the prawn spawner index. There is a high local (HFP) labour input into stock assessments for the diving fisheries.

Other issues relevant to fishing warrant mention as follows:

- Land-based pollution - the low population levels of Haida Gwaii region with attendant low levels of land-based

Table 24. Proportions (%) of landings in selected fisheries according to nearshore versus offshore areas of Haida Gwaii, 1990-2000 (data courtesy of L. Barton, DFO).

YEAR	Geoduck		Dungeness Crab		Prawn		Red Sea Urchin	
	N[1]	O[2]	N	O	N	O	N	O
1990	-[3]	-[3]	>95	*	100	0	*	0
1991	>95	*	75	25	*	0	100	0
1992	-	-	32	68	100	0	100	0
1993	-	-	13	87	100	0	100	0
1994	100	0	22	78	0	0	100	0
1995	-	-	12	88	100	0	100	0
1996	-	-	33	77	>95	*	100	0
1997	100	0	41	59	100	0	96	4
1998	-	-	31	69	100	0	100	0
1999	-	-	34	66	100	0	95	5
2000	100	0	25	75	>95	*	98	2

1 N = nearshore Haida Gwaii (PFMAs 1, 2[E + W])
2 O = offshore Haida Gwaii (PFMAs 101, 102, 130, 142)
3 Haida Gwaii area closed due to rotational (triennial) nature of fishery
* too few fishers landing catch for data to be reported

Table 25. Summary of the management criteria for the major shellfisheries of Haida Gwaii, 1999.

Fishery	Key Management Criteria	Other Management Criteria
Razor Clam[1]	Annual allowable catch based on stock assessment / co-managed between CHN (HFP) and DFO	Limited entry; new fishers now Haida only / size limit
Geoduck Clam[1]	Individual quota of the triennial allowable catch based on stock assessment	Area-licensing / limited entry
Dungeness Crab	Size limit – males only	Area-licensing / limited entry / trap limit per boat / trap criteria to permit appropriate escapement / seasonal soft-shell area closures / industry funds soft-shell assessments
Prawn	In-season assessment of local "spawner index"	Limited entry / size limit / trap limit per boat / trap criteria to permit appropriate escapement
Red Sea Urchin	Individual quota of the annual allowable catch based on stock assessment	Area-licensing / limited entry / size limit

1 catch for human seafood must be certified free of paralytic shellfish poison

pollution render habitat degradation and pollution minor issues compared to some urban and industrial mill-associated south coast areas of British Columbia (Orensanz and Jamieson 1998). For example, there has been no logging in the Gwaii Haanas area since 1987, no other industrial upland activity for decades and there will always be very little built infrastructure in the area. Elsewhere in Haida Gwaii, logging is active and there are downstream effects such as increased sedimentation in nearshore waters. Coal and mineral exploitation were important post-contact exploration and settler attractants (Richardson 1873; Morton 1992). There has been no mining in the Gwaii Haanas area since 1968 when the Jedway Iron Mine (Harriet Harbour) closed. The largest nearby regional mine was in Tasu Sound and it closed in 1983.

- Sea-based pollution – this is a genuine threat, such as oil pollution from a shipping incident offshore or from an oil or gas production platform blowout should development of the known reserves of Hecate Strait occur. Spilled oil can have significant short-term acute affects, long-term chronic effects and oil can persist for decades in sheltered marine shore habitats (Sloan 1999). Recoverable resources are estimated at ≈414 million m^3 [2.6 billion barrels] of oil and ≈565 billion m^3 [20 trillion ft^3] of gas in Hecate Strait (Dietrich 1995). There have been federal and provincial moratoria on exploration in waters around Haida Gwaii since 1972. In 2001, a new British Columbia government wanted to address lifting the provincial moratorium in favor of regional economic development (Observer, July 2001). Debate on the oil and gas issue is about to intensify. Most of the Gwaii Haanas area itself has low petroleum resource potential (Dietrich *et* *al.* 1992). Further, the West Coast Offshore Exploration Environmental Assessment Panel recommended that possible future drilling should be prohibited within an exclusion zone of 20 km from any point of land (WCOEEAP 1986, p. 93). The landward edge of this zone, therefore, would be seaward of the proposed Gwaii Haanas marine boundary [established in the *South Moresby Agreement*, 1988] by ≈10 km. Finally, Gwaii Haanas is further protected in that jurisdiction over seabed lands within the proposed Gwaii Haanas marine area was transferred from British Columbia to Parks Canada by provincial Order in Council in April 2001. All other types of water-borne pollution are less threatening to Haida Gwaii than to, for example, the densely populated and enclosed southern Strait of Georgia.

- Habitat-modifying fisheries – these include heavy bottom trawls used by *"draggers"* in demersal (near-bottom) finfisheries. Watling and Norse (1998) estimated the amount of sea bottom scoured by trawls world-wide annually at an astonishing half of Earth's continental shelf or the equivalent of 150 times all the forest land area clearcut annually! The extent of damage to invertebrate benthic communities by trawls in the Haida Gwaii region is unknown. Heavy trawl gear is not used in regional shellfisheries in Haida Gwaii. Some habitat modification does, however, take place in the sediment disturbance by geoduck divers and in shrimp trawling with light-weight trawls. Their scale and intensity does not compare with the finfish draggers, and, to a lesser extent, finfish long-liners. In the Haida Gwaii region, it is likely that finfish dragging and long-lining does impact deep-water invertebrate populations such as sponge bioherms and coral and sea fan groves. These impacts are not quantified but there is genuine concern for deep-water corals throughout temperate regions world-wide (Risk *et al.* 1998). The whole issue of conservation of deep-water invertebrates is grossly underdeveloped.

- New invertebrate fisheries – some fisheries, such as geoduck, pre-date the intention to create the Gwaii Haanas national marine conservation area as declared in the *South Moresby Agreement* (1988) between the province of British Columbia and Canada. Other fisheries, however, were initiated in the Gwaii Haanas area after that, such as red sea urchin. Still other fisheries are under consideration for development such as Tanner crab. Once the Gwaii Haanas marine area is declared, prospects for new fisheries will be important management issues into which the regional Gwaii Haanas management partnership will contribute.

- Access to full fisheries information – the long-term sustainable, ecosystem-based management envisioned for the eventual Gwaii Haanas management partnership will require access to ALL possible data sources on marine resources. At this time, for example, Parks Canada has no access to the confidential fisheries data such as geoduck fishing areas. Mechanisms will have to be developed by which Gwaii Haanas management will have access to such data while maintaining confidentiality. There is precedent as Gwaii Haanas retains confidential data on Peregrine falcon (*Falco peregrinus*) eyries (nests) through an arrangement with the province of British Columbia. This information can be made available from Gwaii Haanas if written permission is first received by Gwaii Haanas management from the province.

SOCIOECONOMIC OVERVIEW OF HAIDA GWAII SHELLFISHERIES

"Systematic social studies should be conducted to accurately evaluate the impacts of a proposed MPA on community stability." (NRC 2001)

Science and management of these shellfisheries are but a part of the picture. Also needed is a detailed socioeconomic assessment of their impacts to Haida and other communities in Haida Gwaii, the north mainland coast and the whole south coast of British Columbia. The fishers, packers, processors and support services all make appreciable contributions to their home communities. Important questions need to be answered on who benefits from these shellfisheries and who could be negatively impacted by the establishment of the Gwaii Haanas marine conservation area.

A simple way to view the gross economic value of shellfisheries is to look at their annual landed value. The most recent figures are listed in Table 26 for the main shellfisheries of Haida Gwaii. Although only landed every three years, geoduck is by far the most valuable shellfishery. Gwaii Haanas area landed value dominated in the geoduck and the prawn trap fishery. The domination by dive fisheries of shellfish landed value is coast-wide (Harbo 1998). In 2000, a geoduck fishing year, total shellfish landings from Gwaii Haanas alone exceeded $14 million. This is an important number to keep in mind. In public consultation concerning DFO's Gabriola Pass marine protected area, a win-lose polarity developed between the geoduck industry and an environmental NGO (Spisak 1997). It will be essential for the Gwaii Haanas consultation process to be proactive in ensuring that all sectors contribute, enabling a civil and equitable balance of sustainable resource extraction with appropriate conservation area management.

Table 26. Approximate landed (ex-vessel) value of the major shellfish species of Haida Gwaii, 1999 or 2000 (data courtesy B. De Freitas, HFP and L. Barton/J. Davidson, DFO).

Fishery (year)	Landings[1] According to Area (tonnes)		Average Landed Price[3] ($ per kg)	Landed Value According to Area ($1,000)	
	Haida Gwaii	Gwaii[2] Haanas		Haida Gwaii	Gwaii Haanas
Razor Clam (2000)	236.5	0.0	1.96[4]	465.0	0.0
Geoduck Clam (2000)	1,012.6	606.4	23.15[4]	23,440.7	14,037.0
Dungeness Crab (1999)	890.1	0.0	7.41[5]	6,383.5	0.0
Prawn (1999)	77.1	48.8	12.95[6]	998.2	632.6
Red Sea Urchin (1999)	714.1	328.9	1.54[4,7]	1,141.3	506.4

1 based on fishers' log book data

2 Gwaii Haanas comprises 23 sub-areas within PFMAs 2E (sub-areas 2-8 to 2-19 = 12) and 2W (2-31 to 2-41 = 11)

3 coast-wide average (unless otherwise stated); price is ex-vessel or direct to processor and based on sales slip data

4 product type is "round"(whole, shell-on) fresh

5 product type is "live"

6 median of price range ($12.85 to $13.05) is for the PFMA 2E only for which only two of five product types (round fresh and round frozen) were recorded; in 2000, the average price for whole frozen (the only product type currently on record) was $18.74

7 median of price range ($1.51 to $1.58) is for the PFMAs of Haida Gwaii (1/2E/2W) only

The issue of where the licence holders live relates importantly to economic benefits from shellfisheries. Listed in Table 27 are the home locations of commercial licence-holders according to various Haida Gwaii shellfisheries. A reasonable assumption is that most ships' crews tend also to come from the licencees' home areas. With the exception of razor clam and Dungeness crab fishers, few commercial licence-holders live in Haida Gwaii. Such information is important as income from fishers residing elsewhere is less likely to contribute to communities near where they fish. Added to that could be the importance of employment which is currently depressed in coastal communities. An important trend is that of *"communal"* (F) licences. These are licences converted from the general pool and reallocated to First Nations. There are now five communal red sea urchin (FZC) licenses (four north mainland coast / one Haida Gwaii), three communal crab (FR) licences (two Haida Gwaii / one south coast) and two communal prawn (FW) licences (one north mainland coast / one south coast). These represent a process under the Aboriginal Fisheries Strategy to allocate more licences regionally to First Nations.

Shellfish processing is an important shore-based economic attribute of shellfisheries contributing employment and development in coastal communities. Most landed shellfish passes through licensed processing plants. Seafood for export (e.g., all geoduck, all sea urchin, most prawns) must pass through a *"federally registered"* plant to acquire an *"export certificate."* These plants are inspected regularly by the Canadian Food Inspection Agency (CFIA) for compliance with seafood safety regulations (CFIA 1999). Seafood for domestic consumption only (e.g., some prawns and Dungeness crab) passes through provincially-registered plants inspected by the British Columbia Ministry of Fisheries.

Table 27. Registered home areas of commercial licence holders according to Haida Gwaii shellfishery for 2000 (data courtesy of K. Marcus/T. Murray/D. St.Pierre, DFO).

Fishery	Type (number) of commercial licences coast-wide	Type (number) of these licences allocated to harvest in the North Coast area	% of North Coast-allocated licence holders according to area of residence		
			Haida Gwaii	North Mainland Coast[4]	Whole South Coast[5]
Razor Clam	Z2 (NA)	Z2-A[1] (6) + Haida[1] (269)	100	0	0
Geoduck Clam	G (55)	G-N (31)	0	3	97
Northern Abalone[2]	E (26)[2]	E	4	23	73
Dungeness Crab	R (222)	R-A (52)	18	50	32
Prawn[3]	W (250)	W-A (94)[3]	0	17	83
Red Sea Urchin	ZC (110)	ZC-N (91)	1	11	88

NA = not applicable; the 515 Z2 licences coast-wide were for all intertidal clam species, but razor clam is commercially fished in Haida Gwaii only

1 there were 6 non-Haida fishers and 269 licensed Haida fishers digging under the authority of a single communal licence issued to the Haida Nation

2 fishery closed since 1990, but licences are still being held

3 area licensing introduced for the first time in 2000 as a pilot program in which area A was Haida Gwaii + north coast + central coast + west coast of Vancouver island + all offshore areas versus Area B of all inside waters (Queen Charlotte Strait + Johnstone Strait + Georgia Strait + Juan de Fuca Strait)

4 mainland coast north of Cape Caution

5 all of the south coast, south of Cape Caution, including Vancouver Island and Alberta

Shellfish can be landed directly to processors by fishers or delivered to processors by packers in a variety of states. The Haida Gwaii prawn catch, for example, is frozen at sea whereas red sea urchin must reach processors fresh for specialized handling, and geoducks must go through processing and reach their Asian export markets live. The prawn catch destined for export (Japan) is treated on board with a Japanese anti-oxidant to maintain bright colouration. This chemical is not CFIA-approved for domestic use, so the product can only be exported. The data in Table 28 show that, with the exception of all razor clam and 20% of Dungeness crab processing, product tends to be processed off Haida Gwaii. Dungeness crab had the most complex processing geography with appreciable proportions of catch being processed in Masset and Prince Rupert. Although the Masset plants are federally registered, they do not participate much in the overseas export certification of shellfish.

In summary, although the shellfisheries of Haida Gwaii (and Gwaii Haanas) are of high value province-wide, this preliminary assessment reveals that, with exceptions for razor clam and Dungeness crab, most economic benefits from commercial fishing bypass Haida Gwaii communities.

PUBLIC HEALTH AND SAFETY OF SEAFOOD

There are public health risks associated with eating marine invertebrates in Haida Gwaii. Bivalve seafood safety is managed under the Canadian Shellfish Sanitation Program with the following agency mandates:

- biotoxin surveillance and seafood inspection by the Canadian Food Inspection Agency;
- bacteriological water quality surveys by Environment Canada; and
- posting and patrolling of closed areas and the management of conditionally

Table 28. Location of processing of shellfish fished in Haida Gwaii for 1999 or 2000 (data courtesy of B. De Freitas, HFP and I. Winther/L. Barton/J. Rogers, DFO).

Fishery	Amount fished from Haida Gwaii[1] (tonnes)	% of Haida Gwaii catch processed on shore according to region		
		Haida Gwaii	North Mainland Coast[4]	Whole South Coast[5]
Razor Clam[2]	236.5	94	0	6
Geoduck clam[2]	1,012.6	0	0	100
Dungeness Crab	890.1	20	33	47
Prawn[3]	77.1	0	6	94
Red Sea Urchin	714.1	0	0	100

1 based on fishers' log book data
2 for the year 2000
3 most product is treated at sea, before freezing, with an anti-oxidant for the export (Japanese) market which is not approved for domestic consumption
4 mainland coast north of Cape Caution
5 all of the south coast, south of Cape Caution, including Vancouver Island

approved areas by DFO under the *Fisheries Act* – usually on recommendation from the above agencies.

The Canadian Shellfish Sanitation Program arose from a Canada-U.S. Bilateral Agreement observing equivalent standards and is routinely audited by the U.S. Food and Drug Administration (EC 1997). The Sanitation Program's objectives are to minimize the public health risk posed by consumption of Canada's bivalve mollusc seafood. Dungeness crab seafood safety does not fall under this program, but is included in Canadian Food Inspection Agency surveillance.

Paralytic Shellfish Poison (PSP) Biotoxin

Paralytic Shellfish Poisoning (PSP) is caused by several neurotoxins in certain dinoflagellate phytoplankton species. Many species of dinoflagellates can form seasonal (spring/summer) aggregations ("blooms"). Visible blooms are called "red tides" because of their red-brown discolouration of seawater. The blooms are patchy in distribution and their timing and locality are very unpredictable.

Bivalve molluscs such as clams and mussels consume phytoplankton by filter-feeding. When there is a bloom of toxic dinoflagellates, bivalves ingest them in large numbers. Toxins are retained in bivalve species for varying periods of time. People and other warm-blooded vertebrates can be poisoned after eating such contaminated shellfish. The toxin dynamics vary as to bivalve species, for example, butter clams (*Saxidomus gigantea*) absorb toxins gradually and retain them for longer periods, whereas mussels (*Mytilus* spp.) absorb toxins rapidly, but tend not to retain them for as long. The toxin can be fatal through paralysis of breathing muscles causing inability to ventilate the lungs. Symptoms are tingling extremeties, dizziness, nausea, vomiting, abdominal cramps and difficulty breathing. These is no drug treatment; care-givers should call emergency response, induce vomiting and stand-by to initiate cardio-pulmonary resuscitation (CPR) to assist breathing if necessary.

Toxic red tides are well known in British Columbia (Quayle 1969; Martin, 1994) and Alaska (RaLonde 1996). They are also known in traditional Haida stories as described previously in the Haida use section. Given the frequency of red tides along the north coast of British Columbia and the lack of regular PSP testing, the whole region (PFMAs 1 to 10) has been closed by DFO to all intertidal bivalve fishing since 1963 for public health and safety. Gwaii Haanas visitor management policy supports this closure year-round. Areas, such as North Beach on Graham Island, are opened for fishing only after testing. The internationally recognized and approved "mouse bioassay" test, administered by the Canadian Food Inspection Agency is used. The test threshold is a toxin level of >80 µg toxin per 100 g of bivalve tissue. For a closed area to be reopened, the above toxin level cannot be exceeded in any of three samples taken over a 14 day period. The geoduck industry covers the costs of PSP testing of product from Haida Gwaii before full-scale fishing during the years in which they fishing. Subtidal geoduck results cannot be used to open adjacent intertidal areas for clam digging. The Haida Fisheries Program expedites regular PSP testing to maintain the North Beach (sub-area 1-5) razor clam commercial and recreational fishery openings.

Amnesic Shellfish Poison (ASP) Biotoxin

Amnesic Shellfish Poisoning (ASP) is a relatively new biotoxin threat. It was first described from eastern Canada in 1988 where toxic mussels (*Mytilus* sp.) poisoned over 100 persons, a few of them fatally (Ahmed 1991). It is also a neurotoxin (domoic acid) absorbed by bivalves from their phytoplankton (diatom) food. Locally, the toxin has also been found in the digestive organ (hepatopancreas) of Dungeness crabs, perhaps because they are bivalve predators. Toxic symptoms include vomiting, abdominal cramps, diarrhea, disorientation and memory loss particularly of short-term memory. Amnesic Shellfish Poisoning has been recorded from north coast of British Columbia bivalves since the early 1990s, but levels have been generally low. In eastern Canada, levels of >20 µg toxin per one gram of mussel tissue have induced fishing closure. In Haida Gwaii, there has been one ASP closure (North Beach – PFMA sub-area 1-5) for 10 months in 1995-1996 due to toxin levels recorded from razor clam and Dungeness crab.

Shellfish Growing Water Quality (fecal contamination)

Fecal coliform bacteria contamination of Haida Gwaii (including Gwaii Haanas) marine waters is monitored triennially by Environment Canada's Shellfish Water Quality Protection Program executed by the Environment Protection Branch, Pacific and Yukon Region. Fecal contamination can come from human sewage or wildlife feces. Sampling is part of the delivery of the Canadian Shellfish Sanitation Program. If coliform counts are too high, Environment Canada recommends bivalve closures for implementation by DFO under the *Fisheries Act*. For closed areas to be reopened, DFO relies on Environment Canada recommendations based on sample results. Near Haida Gwaii communities, coliform levels have been sufficiently high for DFO to enact the closures illustrated in Figure 32.

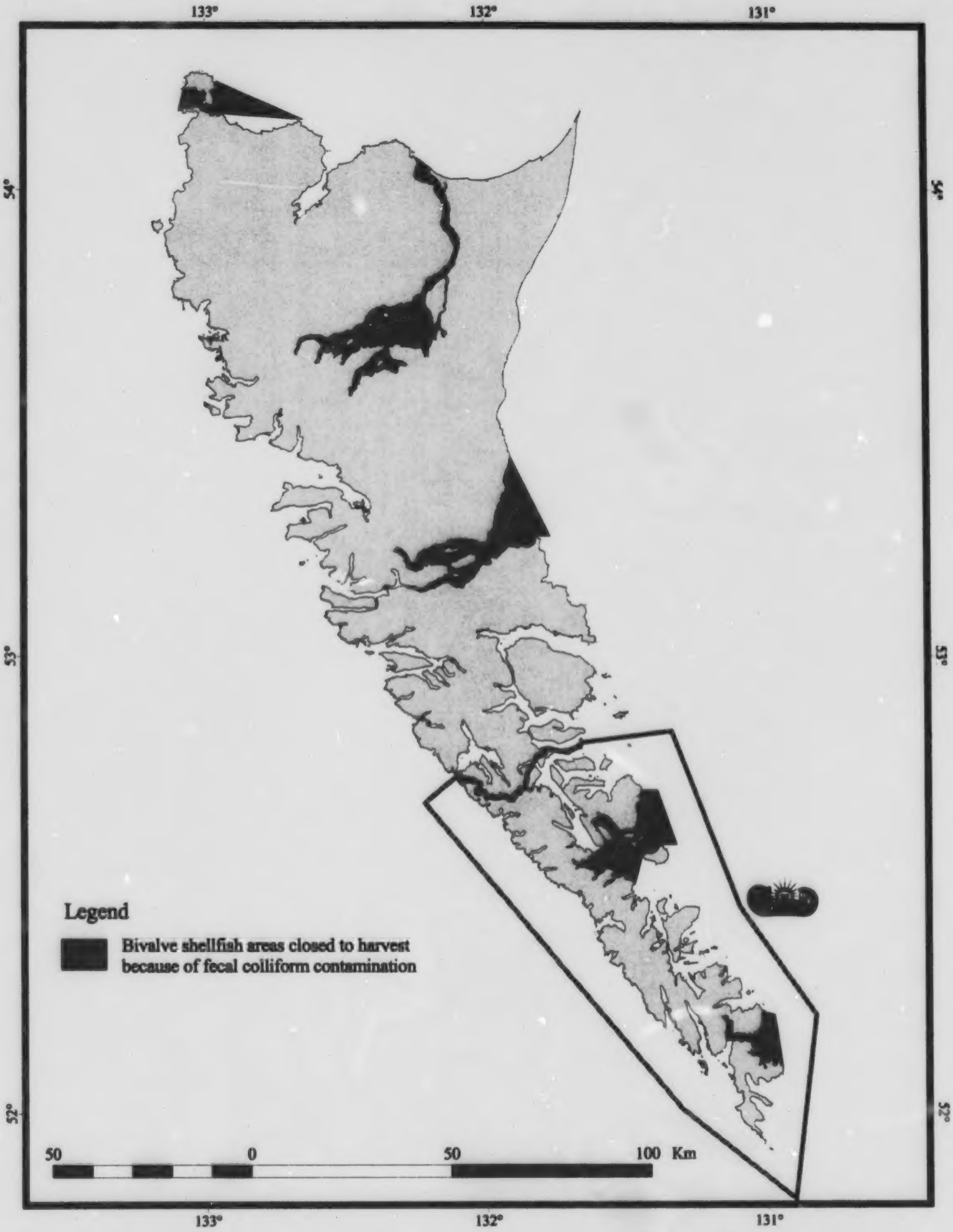
133°
132°
131°
54°
53°
52°
Legend
Bivalve shellfish areas closed to harvest because of fecal colliform contamination
50
0
50
100 Km

Figure 32. Bivalve shellfish areas closed to harvest in Haida Gwaii because of fecal coliform contamination of area waters (Jamieson and Lessard, 2000; and courtesy of G. Jamieson, DFO).

CONTRIBUTION OF MARINE INVERTEBRATE ISSUES TO GWAII HAANAS' MANAGEMENT

MARINE MONITORING

"Without reliable data about rates of change within any habitat, there is no possibility that we can predict the sorts of changes that are likely to be associated with human interferences and developments." (Underwood and Kennelly 1990)

"Long-term ecological monitoring is the first step in learning how to assess ecosystem health." (Davis 1993)

"We need long-term data sets if we are to understand this dynamic world and our impact upon it. We may not be able to make precise predictions about future events, but understanding the past will shed light on our ability to alter natural processes." (Bondrup-Nielsen and Herman 1995)

".... effective scientific research and monitoring programs must be developed together" (Murray *et al.* 1999)

"Well-designed long-term monitoring programs will be necessary to gather data about the pathways of population and ecosystem rebuilding, to assess benefits, to increase knowledge of both fishers and scientists, and to improve the level of protection." (Sumaila *et al.* 2000)

Monitoring is a fundamental component of Parks Canada's mandate for ecosystem integrity in terrestrial national parks (Woodley 1993; Parks Canada Agency 2000) and for facilitating sustainable use without compromising the ecosystem structure and function in marine conservation areas. One of the great benefits of protected spaces such as national parks is their role as long-term regional benchmarks of environmental well-being. An important challenge is achieving acceptance for integrating monitoring costs into long-term operational funding – not short-term research funding.

Although we are in the earliest stages of understanding Gwaii Haanas' marine ecosystems, there is sufficient knowledge and experience to assess our monitoring needs. In the long-term, monitoring will be a foundation of Gwaii Haanas' marine management. And, as invertebrates comprise ≈90% of our marine fauna, they will be fundamental to any monitoring program. An overall monitoring program should be vetted through interagency (Parks Canada, DFO, EC) and public consultation because the data would be a shared regional marine asset. Ideally, appropriate monitoring would both assist Gwaii Haanas management and feature Gwaii Haanas as a major marine environmental reference location for Pacific Canada.

Monitoring should be treated as part of **adaptive management**. This is a structured process of "learning-by-doing" that treats management as an experiment in which hypotheses are formulated and against which findings are used to test these hypotheses. Included in an adaptive management regime are target variables, pre-set values and decision points (management options) established in advance depending on whether explicit performance criteria are met. Monitoring facilitates the feed-back necessary to guide adjustments as the experiment unfolds and instructs managers. Monitoring should, therefore, be experimental and begin with a conceptual model of the ecosystem and be focused on the population dynamics of selected species relative to key ecosystem components and physio-chemical environmental variables (Davis 1993).

Although we cannot monitor all species, we should include as many as possible because they all occupy different niches. Reliance on a few selected species may not reveal meaningful changes in variables such as species diversity. Examples are that mussel densities may remain, but the numbers of species living within the mussel bed infrastructure may vary with different conditions or that important differences between under-rock and on-rock species may occur while one of these communities remains relatively unchanged.

In a major marine area conservation review of science (NRC 2001), the following three tasks were considered central to monitoring:

- assessing management effectiveness;
- measuring long-term trends in ecosystem properties; and
- evaluating economic impacts, community attitudes, involvement and compliance.

To these we would add maintaining scientific accuracy and repeatability.

Parks Canada's marine policy (Parks Canada 1994; Mercier and Mondor 1995) alludes to goals for a monitoring program as follows:

- ensuring long-term viability of marine ecosystems;
- understanding natural spatial and temporal variability in structure (e.g., biodiversity) and function (e.g., production);
- learning how human impacts such as harvest are embedded within the background of natural variability; and
- relating present-day ecosystem conditions to past ecosystem conditions.

The U.S. National Park Service has been monitoring in marine national parks for >20 years. Davis (1993) summarized the utility of the U.S. marine monitoring commitment as follows:

- indicating ecosystem health;
- defining limits of normal variation;
- identifying abnormal environmental conditions; and
- verifying agents of abnormal change.

Channel Islands National Park, CA is the U.S. National Park Service marine inventory and monitoring program model for non-destructive, fixed-site monitoring (Davis *et al.* 1994; Davis *et al.* 1997; Dye 1997 – U.S. National Park Service inventory and monitoring program: http://www.aqd.nps.gov/natnet). Also committed to monitoring on the Pacific coast is the U.S. National Marine Sanctuary program (Monterey Bay National Marine Sanctuary 1999, 2000). California remains the leading Pacific state for marine monitoring (Murray *et al. in press*). Examples are provided below using some of Channel Islands' protocols.

This is a historic time of rapid expansion both in marine monitoring science (Kramer 1994; Schmitt and Osenberg 1996) and governments' commitments to marine monitoring. In Canada, monitoring marine environmental quality is an important initiative for both EC and DFO. Marine monitoring is one of DFO's three components of their Ocean Management Strategy under the *Oceans Act*. Both EC and DFO have collaborated through the National Marine Indicators Working Group to develop categories of marine indicators - parameters tracked over time to reveal trends in processes of interest such as resource use or ecosystem health (Smiley *et al.* 1998; Vandermeulen 1998). The Working Group drafted a five-step process for selecting indicators of marine ecosystems as follows:

- draft as issue statement on reasons for concern within a stress-condition-effect framework;
- substantiate fully the claims of concern for each issue statement;
- explore ecosystem perturbation/ function by linking sections of the framework, e.g., human activity with environmental condition;
- screen the long-list of potential indicators into a working short-list; and
- draft summary report on the deliberations yielding the selected indicators.

DFO has also begun formulating pelagic ecosystem monitoring (Anderson 2001).

Parks Canada has not been part of the interagency marine monitoring cooperation, but this will change in the context of Gwaii Haanas. Fisheries and Oceans Canada has launched a national initiative to facilitate use of indicators towards marine environmental quality (DFO 2000 a). As well, the United States has issued its first nation-wide strategy for coastal marine monitoring (CRMSW 2000 [http://www.cleanwater.gov]). These developments underscore the advances in marine monitoring issues that Gwaii Haanas managers need to be aware of when planning interagency cooperation for monitoring decision-making .

There also is monitoring in aid of ecosystem restoration or rehabilitation within a conservation area. Monitoring could help identify, locate and estimate spatial scale of threats to marine ecosystems. Spatial decision support tools embedded in GIS are being developed for monitoring in marine parks such as the Great Barrier Reef Marine Park (Puotinen 1994). For site management, we must know which threats can be locally managed. Climate change, species introduction and external (non-point source) pollution cannot, although they are worthy of monitoring. On the other hand, habitat destruction and overharvest are manageable within a conservation area. If the spatial scales of threats match those of conservation areas, that should be the prime management focus. However, Parks Canada marine policy is clear that in order to support our regional representation mandate, and in keeping with the openness and dynamism of marine environments, we must be concerned *"well beyond"* marine conservation area boundaries (Parks Canada 1994). For example, we may need to monitor migratory species (e.g., shore birds, whales, salmonids) that occupy Gwaii Haanas only temporarily, but nonetheless have important socioeconomic and ecosystem values. Although active migration is not commonly an issue among invertebrates, larvae and pelagic adults can be transported over long distances. Therefore, invertebrate issues outside of Gwaii Haanas, such as fishing in northern Haida Gwaii, or larval transport from other areas into Gwaii Haanas warrant attention, perhaps through interagency cooperation.

Protected marine areas can also facilitate shellfish stock assessment. In a sea cucumber diving fishery study in Channel Islands National Park, a fishery-independent survey compared stocks in fished and no-take areas before and after the onset of fishing (Schroeter *et al.* 2001). The data revealed that this survey gave more accurate estimates of fished stocks than data based on fishery-dependent (from the fishery) catch per unit effort data. Thus, Channel Island's long-term monitoring commitment and enforcement of no-take areas exemplified parks' potentially *"critically important"* roles in stock assessment (Schroeter *et al.* 2001).

Without interannual data on distribution and abundance of species, comparisons between locations may have limited value (Underwood and Kennelly 1990). Using plant communities, although also applicable to animal communities, these authors proposed the following two stages towards understanding intertidal and subtidal rocky shore communities:

- quantitative studies to describe the patterns of distribution and abundance of species with appropriate spatial and temporal replication to estimate variances among and within shores and among years and seasons; and
- experimental analyses of the processes causing the observed patterns.

The latter is the evolutionary end-point of such work and has not yet been achieved in temperate coastal systems world-wide.

After clarifying management information needs and monitoring objectives, a key challenge is deciding what marine ecosystem attributes, components or associated species to monitor as discussed above from the EC/DFO collaboration. Soliciting the judgement of experts ("Delphi" technique) has been used to select marine invertebrate indicator species from ecosystem components by the U.S. National Park Service (Davis *et al.* 1994). Further, sampling methods must provide unbiased and statistically powerful results while respecting costs and logistics (Gibbs *et al.* 1998). Although threat-specific monitoring will be an important part of a comprehensive monitoring program, it is also necessary to develop an integrated approach to ecosystem monitoring (Robinson 2001).

Monitoring Invertebrates in Gwaii Haanas

Of all the marine invertebrate habitats in British Columbia, the intertidal has historically received the most attention (Lewis and Quayle 1972; Carefoot 1977). At a workshop assessing ecological status hosted by Pacific Rim National Park, intertidal and subtidal communities were among the selected marine environmental indicators with a suite of measures such as community structure, biodiversity indices, recovery of exploited species and behaviour of unexploited species (Rowe *et al.* 1999). Certainly in the last decade, monitoring of intertidal invertebrates alone or along with seaweeds has become common in national marine parks along the Northeast Pacific coast (Table 29). Particularly important for use in monitoring has been the persistence and dominance on rocky intertidal shores by key epifauna groups such as mussels and barnacles. These groups have well known life histories and are amenable to a range of non-destructive monitoring techniques at fixed sites such as photographing quadrats (squares of known area). However, it can also be argued that monitoring should include all of the larger animals not just one or two species, given that each species has a different ecological niche and may be subject to differing stresses. Gwaii Haanas already has a baseline on the occurrence of conspicuous, dominant intertidal invertebrate epifauna to build upon as Harper *et al.* (1994) used invertebrate species as well as seaweeds and other marine plants to discriminate community types from aerial photographs of Gwaii Haanas' shores (see Table 12). We do not have the same for sediment-dwelling infauna.

Sediment infauna have been much less used for intertidal monitoring. Channel Islands National Park, for example, has a sand beach and lagoon monitoring protocol (Dugan *et al.* 1990) using six beach invertebrate species (crustacean and mollusk) and three lagoonal (estuarine) non-insect invertebrate species. In the Broken Group Islands unit of Pacific Rim National Park, intertidal burrowing bivalve populations are monitored to assess levels of beach disturbance (H. Holmes, Pacific Rim National Park, *personal communication).* Although Gwaii Haanas has a coastline

Table 29. Summary of selected intertidal monitoring attributes involving marine invertebrates in National Parks and Monuments from Alaska to California.

Park (Proponent)	Start Date	Frequency* (mo/season)	Notes on the protocols and animal species	Reference
Glacier Bay National Park and Preserve (NPS/USGS[1])	1997	Annual (June)	Used 200 m long shore segments for horizontal and vertical transect and quadrat surveys and a subset of these for finer-scale, more intensive surveys: estimated % cover of mussels (*Mytilus trossulus*) and acorn barnacles (e.g., *Balanus* spp.); counts of mobile species (snails, worms, echinoderms); specific quadrats for densities of littorinid snails, barnacle spat, mussels; estimated of zonation according to dominant species	Irvine (1998)
Pacific Rim National Park (Parks Canada)	1997	Annual (June)	Modified the protocols of the DFO[2] *Shorekeepers' Manual*; 1 m^2 mid intertidal quadrats are used in different rocky habitats (tidepool/ bench/surge channel/vertical face) examined for all conspicuous invertebrate species, number and % cover by volunteer participants	Holmes (1999)
Olympic National Park (U.S. National Park Service)	1988	Biannually[3] (summer)	Method revised in 1997 after sampling experiments in 1996; point-counts and quadrats sampled along transects (10 to 30 m) at various shore levels of rocky or mixed cobble shores ID and count all invertebrates encountered; on sand, take 10 cm diameter cores to 10 cm depth and sieve through 1 mm to retain infauna.	Dethier (1997)
Channel Islands National Park (U.S. National Park Service)	1982[4]	Annual (January)	Permanent quadrats (50X75 cm) are photographed along levels between an uppermost barnacle zone down to the *Mytilus californianus* zone; the image is projected over a 100-point grid for a % cover analysis; abalone are counted, measured and tagged in five fixed 1 to 2 m^2 plots	Richards and Davis (1988) Davis et al. (1994)
Cabrillo National Monument (U.S. National Park Service)	1990	Semi-annual[5] (spring/fall)	Permanent quadrats (50X75 cm) are photographed for estimating % cover of acorn and goose (*Pollicipes polymerus*) barnacle species and *Mytilus californianus*; 1 m radius circular plots in which all owl limpets (*Lottia gigantea*) >15 mm shell length are measured and counted; 10 m line transects for % cover of aggregating anemone (*Anthopleura elegantissima*); 30 min timed searches in which all abalone and seastar species are measured and counted.	Engle and Davis (1996)

* actual or recommended

[1] Two U.S. Department of Interior agencies (National Park Service and U.S. Geological Survey's Alaska Biological Science Center), developed this method for a total of three parks, including also: Katmai National Park and Preserve and Wrangell-St. Elias National Park and Preserve

[2] Department of Fisheries and Oceans developed its *Shorekeepers' Manual* (Jamieson *et al.* 1999)

[3] After 1993 there was even-year and odd-year sampling divided among the 22 rocky shore locations

[4] Anacapa Is. in 1982, expanded to 15 locations among the islands by 1988

[5] Three sites at one location

comprising <10% is sandy shores (≈75% of the shoreline is rocky), sandy/muddy habitats should not be overlooked in selecting intertidal species to monitor, especially as they also represent estuarine habitats.

Subtidal invertebrates are less prominent in parks monitoring than intertidal invertebrates. A major exception is Channel Islands which has been recording 38 invertebrate species within their kelp forest monitoring protocol since the early 1980s (Davis *et al.* 1994). There is, however, a relatively long history of subtidal long-term trend studies from Europe that are applicable to protected area monitoring, but have yet to be widely embraced in North America (Lundav 1986; Hiscock 1987).

An important source of invertebrate monitoring data could come from shellfisheries. Shellfisheries will be an integral part of Gwaii Haanas future so that information on target species will be important to long-term management. Data come from both the fisheries themselves and from fisheries-independent surveys such as diving stock surveys. It may be that some commercial species will become sentinel indicators of Gwaii Haanas' well-being. In recent research projects, shellfish have been useful in demonstrating in-area effects of protected subtidal areas. For example, Edgar and Barrett (1997, 1999) reported from Tasmania that sea urchin and lobster numbers and abalone sizes increased inside protected areas. Kelly *et al.* (2000) found that New Zealand lobster densities, body sizes, biomass and egg production increased inside protected areas. Both studies were comparisons over time between protected and nearby unprotected areas. In British Columbia, northern abalone from a protected area increased in density, size and likely reproductive output (egg production) over time (Wallace 1999). On the other hand, Davis (2000) found that declining pink abalone (*Haliotis corrugata*) densities revealed that the 15 ha Anacapa Island no-take area within Channel Island National Park was too small to sustain historical levels of the species. A potentially useful monitoring tool for recruitment is deploying samplers for post-larval, settling invertebrates. These have proved useful in monitoring abalone and sea urchin settlement (Harrold *et al.* 1991; Davis 1995). A wide range of population parameters of conspicuous subtidal invertebrates can, therefore, be used to monitor efficacy of area protection.

Zacharias and Roff (2001 b) review the ideas about using particular species in marine conservation management. Parks are ideal places to establish long-term invertebrate "biomonitoring." Sessile or sedentary invertebrates, principally bivalves, crustaceans (barnacles, amphipods) and polychaetes, have been used as sentinels of marine environmental quality since the 1960s (Martin and Richardson 1991; Pocklington and Wells 1992). There is an extensive literature in the field of biomonitor invertebrates (Rainbow and Phillips 1993; Kramer 1994; Schmitt and Osenberg 1996). These species accumulate pollutants such as metals and hydrocarbons in their tissues, thus permitting inferences on the bioavailability of contaminants to marine ecosystems. Mussels (*Mytilus* and *Perna* spp.) have been particularly widely used (Dame 1996). Gwaii Haanas has abundant mussel populations as well as long-lived geoduck populations that could function as biomonitors through shell growth parameters (Noakes and Campbell 1992).

In closing, an integrated approach linking offshore and nearshore phenomena will characterize the role of invertebrates in marine monitoring in Gwaii Haanas. Robinson (2001) explained that oceanic processes operate at different spatial and time scales influencing the structure and function of Gwaii Haanas' marine ecosystems. The spatial scales of ocean climate include local (within kilometers), regional (10s to100s of km), coast-wide (100s to1,000s of km), and ocean-basin (≈10,000s km), while the time scales of ocean climate include event (weeks), seasonal (months), interannual (< 10 years), regime (10s to100s of years), and millennial (≈1,000s of years). For example, the Gwaii Haanas continental shelf ecosystem report recommended monitoring fundamental oceanic variables (Robinson *et al.* 1999). As well, the Pacific Rim workshop (Rowe *et al.* 1999) yielded numerous marine environmental indicators such as an "Ocean Climate Index" by assembling remote sensing (satellite) imagery, meteorological data and assessing available physical circulation models. Robinson (2001) demonstrated that abundant data from agencies are available over the World Wide Web concerning large-scale and relatively long-term changes in coastal ocean climate. Most of these data are collected at fine time scales (e.g., days) over relatively long time periods. Parks Canada has a role of assembling and analyzing these data, and providing interpretations, applicable to all marine groups such as invertebrates, for park management.

Marine Tourism and Visitor Effects on Intertidal Invertebrates

Gwaii Haanas had ≈1870 visitors comprising 9,773 visitor-day/nights in 2000. This is among the largest number of "*backcountry*" (wilderness) visitations nation-wide for Parks Canada. There is a detailed Backcountry Management Plan (Gajda 1999) for Gwaii Haanas. Visitor databases on GIS have been maintained since 1997 and there is a commitment to long-term campsite monitoring. Because Gwaii Haanas is virtually uninhabited and has little infrastructure for visitors, self-sufficient camping or commercial tour guiding are the main options. Commercial tour operations account for ≈70% of visitors and ≈75% of these enjoy multi-day trips. All visitors attend a mandatory orientation in which responsible conduct (e.g., no-trace camping) and respect for the environment and Haida culture are stressed. Environmental quality and wilderness values such as undisturbed shorelines and solitude are the major expectations of ecotourist visitors. Most of Gwaii Haanas' visitor impacts are coastal due to small boat (e.g., kayak) access to the intertidal and back-beach use for camping. Gwaii Haanas' uplands are not commonly visited.

The literature on roles of tourism in marine conservation has been dominated by studies in tropical, coral reef areas (Salm 1985; Agardy 1993; Shafer and Benzaken 1998). Concerns included the paradox of increasing tourist and recreation impacts after protected status is declared (Jones 1994) and, therefore, the need for zoning to decrease multiple use conflicts in crowded coastal areas (Agardy 1993). The situation for Gwaii Haanas is different, as its remoteness and attendant high costs for visitation limit tourism pressures. But, that is just for now. What directions future tourism will take, such as small cruise ships or diving operations, are speculative and will require planning. The current visitor effects on Gwaii Haanas are mainly camping, beach walking, fishing and boating.

The field of "*recreation ecology*" (Liddle 1991) began with monitoring trampling effects of visitors to terrestrial parks. Studies have expanded into trampling effects on intertidal rocky shores (Keough and Quinn 1991) and coral reef flats (Hawkins and Roberts 1993). The full range of visitor effects on marine conservation areas include trampling, fishing, diving, boating and off-road vehicles as reviewed by McCrone (2001).

Certain areas of Gwaii Haanas such as Dolomite (Burnaby) Narrows at low tide, experience appreciable visitor traffic including trampling the intertidal biota during visitor season (May to September) daytime low tides, as mentioned by Gajda (1999). This impact is unquantified, but given the adoption of the precautionary approach in the proposed *Canada National Marine Conservation Areas Act*, area closure could be implemented based on trampling concerns until data on such impacts are analyzed. It would be optimal to monitor trampling to objectively verify any ecosystem concerns supporting long-term area closure. The current management recommendation is to promote visitor-vessel float-through rather than intertidal walking.

There is a growing rocky intertidal trampling literature in which protected seashore areas in Australia (Keough and Quinn 1998), New Zealand (McCrone 2001), South Africa (Bally and Griffiths 1989) and the U.S. (Brosnan 1993; Brosnan and Crumrine 1994) have been the sites for assessing visitor effects. Intertidal invertebrates are included in these studies along with seaweeds; turf-forming species being the most resistant. Decreases in size and density of invertebrates have been reported.

Pacific Rim National Park initiated the first visitor impact assessments of the rocky intertidal in Pacific Canada (Rowe *et al.* 1999). The monitoring protocol, based on the DFO *"Shorekeeper's Manual"* (Jamieson *et al.* 1999) is described here in Table 29. Data included observations on barnacles, anemonies and mussels in tide pool, horizontal bench, crevice and vertical rock face substrates. Keough and Quinn (1998), however, stress caution in the use of intertidal species for visitor impact monitors until the natural variation and patchiness of intertidal species are better understood and more discernable from variation caused by human impacts.

Intertidal fishing for subsistence, recreation (food, bait, curio) and sale have been investigated as well. Important rocky intertidal studies for small-scale ("artisanal") commercial fishing come from Chile (Castilla and Fernandez 1998; Castilla 1999), indigenous peoples' gathering from South Africa (Lasiak 1998), and recreational fishing from the U.S. (Addessi 1994) and Australia (Kingsford *et al.* 1991). Studies on effects of indigenous peoples' gathering of infauna from intertidal soft sediments include Australia (Catterall and Poiner 1987) and South Africa (Kyle *et al.* 1997). McCrone (2001) summarized findings and concluded that commercial fishing such as in Chile had appreciable direct effects on target species' abundance and indirect effects on community structure with the removal of targeted predators and grazers (Castilla and Fernendez 1998). Similarly in South Africa subsistence gatherers lowered abundance of filter-feeding mussels and grazers that increased seaweed cover and their attendant invertebrate populations (Lasiak 1998). Recreational effects were localized, usually within 200 m of beach access, but nonetheless significantly reduced some species' densities and modified aspects of community structure (Addessi 1994). On sediment beaches, molluscs and crustaceans vary in their vulnerability to fishing impacts according to their life-histories and refuges (e.g., burying) from human predation. Catterall and Poiner (1987) state that for all intertidal habitats that life-history and habitat information can enable *a priori* prediction which intertidal populations could be most susceptible to depletion. In Gwaii Haanas, marine recreational fishing is permitted although there is total closure of all bivalve mollusk species due to the threat of paralytic shellfish poisoning and for northern abalone due to low stocks. Recreational fishing of other groups such as crustaceans (prawn and crab) by trapping is permitted.

Motorized vessel traffic in Gwaii Haanas is from the commercial fishing and tourism industries and independent visitors. Grey-water (toilet) discharge and fuel spills appear the most likely impacts. Commercial tour operators have been asked to limit anchoring at any one location to no longer than three days. The Gwaii Haanas warden service has recently implemented the MILES + Occurrence Database for recording incidents relevant to public safety, law enforcement, environmental protection and resource management. In time, this will help develop an understanding of the actual threats by a wide range of visitor boating activities in Gwaii Haanas.

THE CONTRIBUTION OF SHELLFISHERIES TO MARINE AREA MANAGEMENT

"…. without a knowledge of the ecology of larvae an understanding of the benthos is quite impossible." (Scheltma 1986)

"Recent work in marine ecology has reaffirmed an insight from fisheries science that knowledge about the production, dissemination and success of propagules can guide our management of populations and assemblages." (Fairweather 1991)

"Appropriately designed fishery refugia may be one of the tools used to address the management and rehabilitation of coastal stocks and ecosystems in the next century." (Dugan and Davis 1993a)

"In coastal marine systems, physical oceanographic processes affecting larval stages are as, or more important than, biological interactions affecting adults." (Roughgarden *et al.* 1994)

"Many harvested marine invertebrate populations are metapopulations, composed of relatively sedentary subpopulations connected by dispersing larval stages." (Botsford *et al.* 1998)

"Incorporation of selected species dynamics into MPA rationalization may have to be based on extrapolation from existing data, common sense and intuition rather than hard scientific evidence." (Jamieson and Levings 1998)

"Predicting the consequences of the interaction between reserve configuration and the connectivity pattern is critical to the design of optimally functioning reserves, but prediction requires detailed information not only on life-history characteristics and abundance patterns for the target species but also on hydrodynamic current patterns." (Stockhausen *et al.* 2000)

"The greatest potential increases in yield as a result of protected areas are achieved with spatially persistent, i.e., relatively sedentary species." (Jamieson and Levings 2001)

It is relevant to analyze how shellfish-associated knowledge may aid consultation towards management of marine area conservation. The citations above reveal the critical importance of larval dynamics to adult benthic invertebrate populations and underscore perhaps the core science-based issue confronting marine area conservation. The art of marine area conservation for Parks Canada and its partners in Gwaii Haanas will be to manage multiple sustainable uses, such as commercial fishing, while maintaining long-term ecosystem structure and function. Indeed, if the proposed *Canada National Marine Conservation Areas Act* is passed, management *"…without compromising the structure and function of the ecosystems"* [section 4(4)] would be the law – not an option. Further, this varies from the *Oceans Act* that, although supporting the ecosystem approach in its preamble, does not explicitly mention ecosystem structure and function in its section 35 on marine protected area management criteria. Secondly, therefore, the challenge will also be to observe and balance the legislated mandates of other agencies (e.g., DFO, EC, NRCan) within marine conservation areas.

Overall, fisheries science can contribute much in support of the broader context of marine conservation (Fairweather 1991; Jamieson and Levings 2001). Conversely, promoting the potential contribution of protected marine areas to fisheries research has been a recurrent theme from the beginning of the technical (non-fisheries) marine conservation literature (Wallis 1958), and remains an important consideration (Levings and Jamieson 1999). Further, much has been written about marine conservation areas as instruments of fisheries management including as "insurance" against effects of over-fishing (Allison *et al.* 1998; Guenette *et al.* 1998; Lauck *et al.* 1998; NRC 1999, 2001). The key point is that, through appropriate knowledge-based management, protected marine areas can be an asset to nearby fisheries.

Gwaii Haanas could be useful for exploring adaptive shellfisheries management. Results could provide feed-back enabling managers to learn-by-doing and alter management to achieve desired shellfishery performance criteria. Orensanz and Jamieson (1998) suggested that creation of marine conservation area networks should employ adaptive shellfish management to learn from the natural system's responses. Adaptive management is still not being applied widely in marine conservation (Walters 1997; Parma *et al* 1998), although it is gaining acceptance (Jamieson and Levings 2001). In British Columbia, adaptive shellfish management is being applied to sea cucumber management on a trial basis as well as to new and developing fisheries (B. Adkins, DFO, *personal communication*).

Zoning, Fishing and Refugia

"*......management for direct use (e.g., fisheries), for indirect use (e.g., heritage and existence values), and for ensuring protection of essential ecosystem services, ultimately must be accomplished through zoning, which requires designating different areas to meet different goals.*" (NRC 2001)

"*Renewable resource conservation through protected areas may imply some probable restriction of human fishing activity but is likely to enhance achievable yields in adjacent exploited areas.*" (Jamieson and Levings 2001)

Coexisting ecologically sustainable uses are enabled by zoning. Zoning includes the notion of refugia ("no-take" areas), which are a vibrant topic in coastal fisheries and marine conservation thinking (Dugan and Davis 1993a,b; Botsford *et al.* 1997; Roberts 1998, 2000; Hastings and Botsford 1999; Murray *et al.* 1999; NRC 1999, 2001; Dayton *et al.* 2000; Sumaila *et al.* 2000; Roberts *et al.* 2001; Sloan 2002).

Shellfish issues will contribute to defining Parks Canada's policy commitment to zoning in marine conservation areas such as Gwaii Haanas (Parks Canada 1994). The shellfish species in Haida Gwaii with benthic adults comprise local sub-populations connected by planktonic larval dispersal. That is, benthic adult shellfish populations are relatively "*spatially persistent*" (Orensanz and Jamieson 1998; Jamieson and Levings 2001). Recruitment is meant here, not in the strict fishery sense, but in the broad sense of addition of new individuals to populations (Caley *et al.*

1996). Of course, besides sound science, achieving zoning must be done through the commitment to appropriate public consultation – accepted as critical to success in marine conservation (Sumaila *et al.* 2000).

On the science side, sizes of refugia depend, in part, on the dispersal ability of species or species groups targeted for conservation. Their size may also depend on how well they are buffered from outside impacts. Which areas are *"sources"* (contribute disproportionately large numbers of recruits) and which are *"sinks"* (receive recruits but contribute little) of recruits is critical management information (Ogden 1997; Ballantine 1997 a,b; Jamieson and Levings 1998; Roberts 1998, 2000; Roberts *et al.* 2001). The Great Barrier Reef Marine Park, for example, has for some time looked at how larval dispersal modeling can support zoning (James *et al.* 1990). Botsford *et al.* (1994) warn, for example, that spatially managed populations of red sea urchins would go extinct if distances between refugia exceed the scale of larval dispersal.

It is ironic that the core marine area conservation connectivity ("source/sink") issue should also be widely recognized as perhaps the greatest unsolved question in marine biology – that is, the degree of connectedness between local populations (Scheltema 1986; Gaines and Bertness 1992; Caley *et al.* 1996; Hunt and Scheibling 1997). Caley *et al.* (1996) summarized the basic unresolved science issues in recruitment as follows:

- poor understanding of why recruitment varies in space and time;
- limited knowledge on the extent to which spatial and temporal variation in recruitment influence variation in adult populations; and
- perhaps the most difficult and important gap in understanding benthic and demersal (near-bottom) populations is the relative importance of recruitment versus post-recruitment processes in determining population size and structure, i.e., to what extent does population abundance depend on recruitment (establishment of initial population pattern) compared to competition/predation/facilitation/disturbance (modifiers of population pattern).

The implication is that, for years to come, our scientific understanding of processes fundamental to marine conservation will lag behind the pressing need for implementation. Hence, the important role of the precautionary approach. Ludwig *et al.* (1993) were among the first to champion not waiting for science consensus before creating marine reserves as a common-sense precautionary measure. We should be guided by the precautionary approach and an ecosystem viewpoint (both Parks Canada and DFO commitments) blended with an adaptive management ethic, what science we do know and *"common sense and intuition"* (Jamieson and Levings 1998).

On the socioeconomic side, the unique rights of First Nations and the interests of other stakeholders such as the commercial fishery sector, coastal communities, government agencies and NGOs must blend to reconcile the complexities of conservation, commerce and culture.

Insights Provided by Shellfish Species

"Given the sedentary life-history characteristics of invertebrates and the nature of their fishing process, management measures that explicitly acknowledge spatial structure are most suitable." (Orensanz and Jamieson 1998)

Biology combined with commerce intensifies focus on the roles of commercial species in marine area conservation. Yet, from the 1995 North Pacific Symposium on

Invertebrate Stock Assessment and Management in Nanaimo, Orensanz and Jamieson (1998) concluded that *"Conservation issues may have been the most significantly underrepresented topic at this Symposium."* In other words, these are early days for implementing linkages between shellfisheries management and marine area conservation beyond single species area closures. The spatial persistence of many benthic marine invertebrates makes them good study subjects for conserving marine areas. A sound approach to science-based management includes characterization of potential zones with their associated invertebrate species. This could put Gwaii Haanas at the forefront of marine conservation science in Canada.

Patchy adult shellfish populations associated with identifiable habitat or ecosystems types, such as geoduck in sand beds or northern abalone on kelp-forested rock reefs, facilitate potential zone demarcation. Further, the dispersal capabilities of these species' larvae provide insights into scale and connectedness for planning zone numbers, sizes, shapes and locations. Having said that, be warned that both the invertebrate species' biology and nearshore oceanography in Gwaii Haanas are poorly known. Therefore, blending biology and oceanography in conservation area development will long be a work-in-progress.

There is immense variety in the early life-history traits among marine invertebrates with benthic adults (Scheltema 1986). Looking at the larval lives of invertebrates is important. Invertebrates tend to have more limited dispersal potential than fishes and planktonic larval duration is often, but not necessarily, related to the geographic range of adult invertebrates (Bradbury and Snelgrove 2001). A good example is the brittle star *Amphipholis squamata* that bears live young (i.e., no larval phase), yet has a cosmopolitan (Pacific and Atlantic) distribution. Larval dispersal distances range from settlement near the parental stock (Young and Chia 1982) to settlement more than 2,000 km away from spawning adults (Booth and Phillips 1994). Durations of planktonic larval phases range from two hours (Strathmann 1987 - tunicates) to two years (Booth 1994 – spiny lobsters). Finally, some invertebrates, such as many snail species, have no free-living larval stage.

As examples of this variability among Haida Gwaii shellfish species, Table 30 lists biological characteristics of five species with benthic adults. Just among these species, benthic adult life-history and planktonic larval life-history vary dramatically. These are just five among the thousands of marine invertebrate species in the Haida Gwaii region!

At one end of the spectrum is northern abalone with the following characteristics:

- sedentary adults that form pre-spawning clusters for synchronous spawning;
- external fertilization of broadcasted gametes for which fertilization efficiency declines with a decline in adult densities; and
- short-duration, non-feeding larvae unlikely to travel far before settling.

Therefore, the patch size, location and spacing of adult populations is critical.

At the other end of the spectrum is Dungeness crab with the following characteristics:

- semi-sedentary adult males (tagged crab can move >60 km [I. Winther, DFO, *personal communication*]) which pair and copulate with post-moult (soft-shelled) females;

Table 30. Selected life history criteria of five commercial shellfish species of the Haida Gwaii region (data from DFO Integrated Fishery Management Plans, A. Campbell and C. Hand (DFO) and Sloan and Breen (1988)).

Species	Life Span (years)	Age at Sexual Maturity (years)	Fertilization	Larval Feeding Mode	Larval Period (days)	Adult Feeding Mode
Geoduck Clam	>160	6	External[2]	Plankton eater[3]	40-50	Filter-feeder[5]
Red Sea Urchin	50	4	External[2]	Plankton eater[3]	40-65	Herbivore[6]
Northern Abalone	25	3	External[2]	Non-feeding[4]	6-10	Herbivore[6]
Dungeness Crab	8	2	Internal	Plankton eater[3]	80-110	Carnivore[7]
Prawn	4	1.5[1]	Internal	Plankton-eater[3]	70-84	Carnivore[7]

1 prawns mature as males at ~18 months, then become females in another 12 to 15 months and die as females
2 separate sexes broadcast eggs or sperm, perhaps synchronously, into the water column
3 "planktotrophic"
4 "lecithotrophic"
5 filters plankton from the water column
6 scrapes attached seaweed and/or entraps drift seaweed
7 active predators and/or opportunistic scavengers

- sperm retention for subsequent fertilization and fertilized egg retention by brooding females until larvae hatch; and
- long-lived, feeding larvae that travel 100s to 1,000s of km and mix broadly in offshore waters before returning inshore to settle, perhaps very distant from their location of hatching.

There is not a clear linkage of the densities of adult Dungeness crab populations with the production of larvae by those populations. It is possible, however, to model the influence of near-shore current patterns on spatial distribution of Dungeness crab recruitment at a scale of 100s of km (Crawford and Jamieson 1996; Wing *et al.* 1995, 1998).

Figure 33 illustrates likely applicable models of northern abalone and Dungeness crab larval replenishment adapted from Carr and Reed (1993). These models assume reef-dwelling adult populations, which Dungeness crab is not, but the illustration nonetheless summarizes the Dungeness crab situation. The two

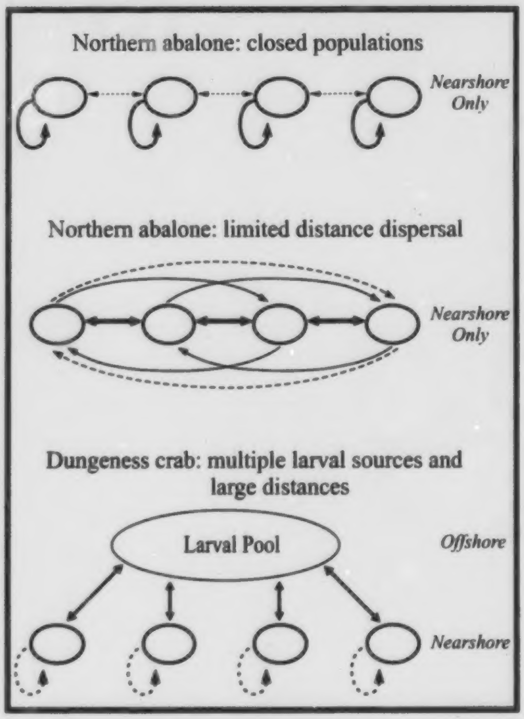
Northern abalone: closed populations
Nearshore Only
Northern abalone: limited distance dispersal
Nearshore Only
Dungeness crab: multiple larval sources and large distances
Larval Pool
Offshore
Nearshore

Figure 33. Models of northern abalone and Dungeness crab larval replenishment (adapted from Carr and Reed (1993)). Ellipses are isolated adult populations. Bold solid lines indicate highest recruitment rates within and/or between ellipses and dotted lines indicate lowest recruitment rates.

northern abalone scenarios are of potentially closed populations (e.g., perhaps Kunghit Island populations are separated from Langara Island populations) and limited distance larval dispersal (e.g., connectivity between Houston Stewart Channel and SGaang Gwaii populations). Recruitment of red sea urchins in northern California has now been linked to relaxation of winds that induce upwelling (Morgan *et al.* 2000). This enabled larval delivery from offshore areas to coastal areas back across the continental shelf. There are insufficient data to link this process driving spatial recruitment patterns to fishable adult abundance (Morgan *et al.* 2000), but this will come.

The fecundity of all species in Table 30 is great. Females of all species except prawns and crabs produce eggs by the million each season and most have the high-risk strategy of external fertilization of broadcasted gametes in the water column. For example, a female northern abalone of 135 mm shell length was estimated capable of producing 7.8 million eggs annually (Campbell *et al.* 1992). Female geoduck have a dramatic fecundity, producing hundreds of millions of eggs over an active reproductive life perhaps exceeding a century. There is, therefore, likely no shortage of juveniles of these species, but few larvae survive to successfully settle, because larvae "*.... lead transitory lives of great risk and grave uncertainty*" (Rumrill 1990).

Concerns of ecosystem-related effects of harvest of dense shellfish populations are beginning to contribute to management decision-making. For example, a potential goose barnacle fishery has set a precedent as the first species to be closed by DFO Pacific coast-wide (in 1999), solely for reasons of potential ecosystem impacts of harvesting. The concern was that harvesting the barnacle clumps, along with California mussel – the other community dominant, could damage the essential microhabitat that goose barnacles and California mussels provide for ≈300 other species (Jamieson *et al.* 1999; Schmidt 1999; Jamieson and Levings 2001). This is a manifestation of a broadening fisheries mandate for conservation beyond the well-being of single species. Further, this underscores the need for ecosystem (not species) reference points for evaluating what are acceptable levels of ecosystem impacts of fisheries (Jamieson and Levings 2001). Ecosystem-based fisheries management will be an increasing influence in regional marine conservation and an opportunity for deepening inter-agency cooperation.

Case Study: Northern Abalone

Northern abalone cannot currently be fished legally by anyone, and the species' cultural, species-at-risk and political profile is high (Neis *et al.* 2000). Further, there is high black market value stimulating poaching (Campbell 2000). The Gwaii Haanas area is a major stronghold for this "threatened" species and, therefore, a strategic opportunity is at hand to work with partners in using Gwaii Haanas for long-term northern abalone restoration in keeping with Parks Canada policy (Parks Canada 1994, subsection 3.1.2). Provided that there is consensus and clarity on the population objectives for northern abalone, the species is well suited for inclusion in marine area protection (Jamieson 2000).

The model of local, sub-populations linked by larval dispersal into genetically distinct metapopulations is robust for abalone species (Keesing and Baker 1998). Northern abalone (and red sea urchin) are exemplary in their spatially persistent clumping. Abalone restoration is certainly amenable to a range of refugia-based strategies (Davis 2000). Understanding the dynamics of clump size, density and between-clump proximity and connectivity will be central to sustainable management (Quinn *et al.* 1993; Shepherd and Brown 1993). Further, being a kelp forest-associated species, northern abalone is a useful surrogate for exploring implementation of area-based conservation. Finally, we already know that northern abalone respond well to area protection by increasing in density, average body size and reproductive output in British Columbia refugia (Wallace 1999).

Abalone can be affected by other shellfish species where there are ecological or behavioural interactions between them. In their worldwide review, Andrew and MacDiarmid (1999) reported that high densities of sea urchins may have a negative effect on abalone populations. This may be related to two species competing for the same sea weed food supplies. Perhaps a fishery for one species could make more food available for adults of the other species? However, in both California (Rogers-Bennett and Pearse 2001) and South Africa (Mayfield and Branch 2000), the spine canopies of adult sea urchins provide a refuge for young abalone. The California study suggested that red sea urchin fishing could decrease important hiding habitat for abalone species. The South African study suggested that a lobster (sea urchin predator) fishery would decrease predation pressure on the sea urchins, thus increasing the amount of hiding (sea urchin spine canopy) habitat for abalone. In other words, abalone can be involved in cascading effects between different shellfish species according to which species is locally fished. The multispecies ecosystem approach, therefore, needs to be used in both fisheries and marine area management.

Numerous studies are now available demonstrating the benefits to shellfish populations provided by protected areas mentioned previously. A report on the genetic characteristics of Haida Gwaii northern abalone populations collected from sites throughout the archipelago is in preparation (R. Withler, DFO, *personal communication*). Such information can reveal the distinctiveness of abalone populations (Withler 2000). Local information could provide insights on the appropriate spatial scale for northern abalone stock rebuilding and area conservation efforts. The application of genetic knowledge to marine area-ecosystem conservation and fishery management is underutilized (Policansky and Magnuson 1998). Clearly, genetics studies have tremendous potential in future marine area conservation science.

The following are examples of topics on northern abalone that could be explored:

- *would protecting northern abalone habitat areas lead to enhanced larval settlement in adjacent (fishable) areas?* – The issue of net export of recruits from protected areas to adjacent areas is the key unanswered science question in marine area conservation. Science has not yet demonstrated this potential benefit (NRC 2001) and this will be very important in consultations with the fishery sector (Jamieson and Levings 2001);

- *can fisheries biology reference points be applied to northern abalone population restoration?* – for example, this could relate to comparing total egg production of a population of individuals permitted to grow to their full potential size with that of the proportion of a population fished (theoretically) above the old legal size limit [100 mm shell length for northern abalone pre-1990 closure] and asking how does this relate to differences in recruitment success? (Shepherd and Baker 1998);

- *what is the spatial scale of larval source/sink dynamics of northern abalone metapopulations?* – this relates to refugia sizes [sufficient densities to maintain adequate fertilization, larval production and recruitment], shapes [in order to maximize kelp forest habitat inclusion], locations [species' optimal habitat criteria and distance between sub-populations] and connectedness [sub-population linkage by larval transport by nearshore oceanographic processes and according to different larval residence times in the plankton] (Tegner 1993);

- *can northern abalone genetic studies provide insight into the connectedness between sub-populations in Haida Gwaii or Gwaii Haanas?* - this could enable spacing no-take northern abalone areas within Gwaii Haanas based on known genetic connectivity between those sub-populations; and

- *do the spine canopies of red sea urchins provide important hiding spaces for young northern abalone?* - this could link abalone well-being to red sea urchin fisheries effects.

Case Study: Geoduck Clam

Geoduck have great commercial importance in Gwaii Haanas and will be a key linking species between the fishery sector and all other stakeholders. There is increasing focus on the engagement of the British Columbia fishery sector into marine area conservation (Burrows 2000; Symington and Jessen 2001). Undisturbed geoduck populations consist of dense populations of old clams whose beds are presumably stable over long periods and whose biomass likely dominates the infauna of these sand bed ecosystems. Because this species is so important commercially, and because its life-history (excluding stock assessment) is not well understood for the Haida Gwaii region, geoduck are an important conservation area science target for better biological understanding.

The following are relevant topic areas in early geoduck life-history applicable to Haida Gwaii conservation-related science:

- *would protecting geoduck habitat areas lead to enhanced larval settlement in adjacent (fishable) areas?*

- *what is the spatial scale of larval source/sink dynamics between geoduck sub-populations within their regional metapopulation?*

- *how does fishing affect the diversity and abundance of other species in the fished area?*

- *what are the impacts of fishing on juvenile geoduck?* – relates fishing impacts to unearthed larvae or juveniles being eaten by opportunistic predators (not unlike predation following gray whale (*Eschrichtius robustus*) bottom-feeding (Oliver and Slattery 1985)) and exacerbated by the possibility that geoduck larvae are alleged to settle near (attracted to?) adults;

- *what is the importance of the refuge for geoduck that live below safe, compressed air diving depths (>30 m) to maintaining populations at fishable depths?* – relates to whether shallow-water refugia are needed if there already are refugia (at depth) for the unfishable proportion of the population; and

- *does fishing improve larval geoduck settlement opportunities in crowded clam beds?* – relates to the issue of whether beds thinned by fishing could provide better (less cannibalism of larvae?)

settlement opportunities compared to crowded (unfished) beds.

Case Study: Sea Otter–Shellfish Interactions

Sea otters were heavily hunted in the immediate post-contact era of ≈1790s to 1840s (Gough 1989; Gibson 1992; Robinson 1996). By the early 20th century, they were considered effectively extirpated from the Haida Gwaii region (Watson *et al.* 1997). They have been internationally protected since the 1911 Northern Fur Seal Treaty signed by the U.K. (for Canada), U.S., Japan and Russia. They are protected federally under the *Fisheries Act* and provincially under the *British Columbia Wildlife Act*. Finally, they are listed as *"threatened"* in the EC species-at-risk database and *red*-listed (*"endangered – threatened"*) at the Conservation Data Centre, Victoria, British Columbia.

There have been three published sightings in Haida Gwaii, all from the Gwaii Haanas area, between 1972 and 2001 (Table 31). All were of single individuals, likely free-ranging males. There is another report (no photographs) by Patche (1922) who mentioned a sea otter skull from a cabin near Rose Spit plus one killed in 1921 and 27 taken in one day in ≈1890 by Old Massett villagers. Recently there have been anecdotal reports. These could be mistaken identity with the river otter (*Lutra canadensis*), which is common in Haida Gwaii. There is as yet no indication of sea otters establishing breeding populations in the Haida Gwaii region.

The removal of sea otters from Haida Gwaii has undoubtedly effected kelp forest-associated species such as northern abalone and red sea urchin. The intense predation effects of sea otters on shellfish species in the Northeast Pacific are well known and these effects are mentioned for each of the species discussed above. Watson and Smith (1996) and Watson (2000) speculated that the absence of sea otters allowed some invertebrate stocks, such as northern abalone and red sea urchin, to accumulate to unnaturally high levels. Further, there likely was widespread decline in kelp abundance after release of red sea urchin populations from sea otter predation pressure in Haida Gwaii.

The possibility that commercial red sea urchin fishing could have similar effects of increasing kelp abundance as predation on red sea urchins by sea otters seems unlikely. One reason is that divers fish only certain areas. They select areas for highest potential roe yield such as red sea urchin feeding front aggregations (*"feed lines"*).

Kelp forest expansion would contribute increased amounts of organic material (food) cycling through nearshore ecosystems with an attendant *"trophic cascade"* (Sala *et al.* 1998) for species groups benefiting from the increased food into the system. In Gwaii Haanas, reestablished sea otter populations would likely lead to kelp population increases with a related trophic cascade, but also decreased northern abalone, red sea urchin and intertidal clam populations. In the north and east Graham Island areas, there could also be decreases to the commercial Dungeness crab stocks by sea otters.

In summary, there are two possibilities for the return of breeding sea otters populations. Firstly, breeding populations of sea otters could reasonably be expected to reestablish in Gwaii Haanas naturally. Expanding populations, perhaps originally from northwest Vancouver Island where they were reintroduced, could have been the source of free-ranging males into the Haida Gwaii area over the last 30 years. Sea otters are physiologically capable of swimming from the mainland coast directly across Hecate Strait (from the Goose Island group into which they are now known to have expanded from the south) or across Dixon Entrance from southeast Alaska. Reestablished sea otters populations in Gwaii Haanas would be actively protected by Parks Canada as part of its ecosystem restoration mandate described below. We should, therefore, anticipate eventual expansion throughout Haida Gwaii as, elsewhere in British Columbia and Alaska, once reintroduced to areas from which they were extirpated, populations can expand at a rate exceeding 18% annually (Watson and Smith 1996; Woodby *et al.* 2000). Secondly, sea otters could be repatriated to Haida Gwaii or Gwaii Haanas by humans. This introduction would likely be accompanied by a vigorous population expansion to the whole archipelago. There is precedent in British Columbia with the successful introduction of 89 Alaskan (Aleutian Islands) sea otters to Checleset Bay on the northeast coast of Vancouver Island by the province of British Columbia and DFO between 1969 to 1972 (Watson *et al.* 1997). This stimulated a Haida Gwaii NGO of the day (Islands Protection Society) to promote an introduction into Haida Gwaii (Anonymous 1976). In 1987 the province of British Columbia formally proposed to DFO an introduction of Alaskan stock to Haida Gwaii (preferred sites of SG̲aang Gwaii and Hippa Island; alternate sites of Englefield Bay and Skincuttle Inlet). There was a public meeting in Masset in January, 1988 at which both opposition and support was expressed (M. Hearne, Masset, *personal communication*). The introduction was not done.

Parks Canada policy does allow for active marine ecosystem restoration (Parks Canada 1994). In sub-section 3.1.4 of the policy's "Ecosystem Management" section, restoration of extirpated species is supported in principle provided that "*….research has shown that reintroduction is likely to succeed and that its probable effects are acceptable within the conservation area and the surrounding region.*" In either case of natural or human-influenced return of sea otters, it would be imperative to consult all stakeholders to enable an understanding of anticipated ecosystem and shellfishery outcomes.

Table 31. Published sea otter (*Enhydra lutris*) sightings reported from the Haida Gwaii region; all are from the southern Gwaii Haanas area.

Date	Location	Notes	Reference
July 25, 1972	Cape St. James, 51°55'N, 131°00'W adjacent to the sea lion rookery	Reported by a sea lion researcher – a 35 mm slide was taken and put on file with the RBCM [1]	Edie (1973)
August 30, 1976	Flamingo Inlet, 52° 12'N, 131°20'40"W opposite Sperm Bay	Reported by scientists on a botanical and anthropological expedition – no photograph taken	Taylor and Gough (1977)
July 11, 2001	SG̲aang Gwaii (Anthony Island), 52° 04'58"N, 131°13' 49"W beside a sea lion haulout on an islet south of the main island	Reported by Alaska Department of Fish and Game and Parks Canada warden staff while on a sea lion survey – photographs taken	Raum-Suryan *et al.* (*in preparation*) - Digital photos on file at Gwaii Haanas (Parks Canada) office

[1] a copy of the original slide taken by A.G. Edie was provided courtesy of M. McNall, Royal British Columbia Museum (RBCM) and is on file at Gwaii Haanas office

CONCLUSIONS AND RECOMMENDATIONS

"Conservation is a positive experience of skill and insight, not merely a negative exercise of abstinence and caution" (Aldo Leopold, from Callicott 1992)

"But if I had to name the single most frightening and dangerous threat to the health of the oceans, the one that stands alone yet is at the base of all others is ignorance: lack of understanding, failure to relate our destiny to that of the sea, or to make the connection between the health of coral reefs and our own health, between the fate of the great whales and the future of humankind." (Earle 1995)

"The long-term survival of most species and ecosystems also requires large and interacting populations to ensure diverse genetics, health and reproductive success, and large areas to provide habitats and nourishment. This further supports the need for partnerships to protect and manage biodiversity." (Industry Canada - IC 2000)

The wisdom of Aldo Leopold resonates with us, but ignorance of regional marine biodiversity, biogeography and ecosystem function necessitates the precautionary approach. In the long term, however, using skill and insight are the operational ideals. As E.O. Wilson has said: *"There is an implicit principle of human behavior important to conservation: the better an ecosystem is known, the less likely it will be destroyed."*

Gwaii Haanas is a great opportunity for Canadian innovation in marine area conservation. This report will have succeeded if readers find it facilitates discussion of technical issues during public consultation towards establishing Gwaii Haanas marine area under a consultative, knowledge- and ecosystem-based partnership.

Invertebrates are fundamental to local marine ecosystem structure and function, yet we know so little about them. Invertebrates are important culturally and economically. Finally, invertebrates have intrinsic value and the ethical right to coexist with us. Appreciating the breadth of invertebrates' importance and our moral obligations to them is progress. But, further progress can only be made through new thinking about applying ecosystem-based science to marine area conservation, better ways to involve the public, new attitudes about interagency - stakeholder consultation and full exploitation of computer-based technologies such as GIS.

We recommend the following:

- **document traditional Haida knowledge and usage of marine invertebrates**

Considering that marine invertebrates were likely important to the survival of indigenous people for ≈10,000 years in the Haida Gwaii region, we have only a small published knowledge-base. Much more documentation of Haida oral history, traditional knowledge and archaeology is required. Some has been published, but we expect that much knowledge has already been lost. This issue is important in its own right as well as in view of the Canada-Haida cooperative management partnership currently underpinning Gwaii Haanas' land management.

The passing of Elders, who had relatively traditional rearing, represent particularly significant losses of traditional knowledge if their stories are not recorded. Some unexamined audio-tapes of deceased Elders do exist. These must be fully evaluated along with interviews with living Elders. Currently, Gwaii Haanas' is working with the Skidegate Haida Language Authority for GIS mapping of traditional knowledge (names, songs, stories) associated with locations in southern Haida Gwaii. Also, an intensive archaeological study of pre-contact Haida diets from coastal habitation sites has begun that likely will reveal much more on historic marine invertebrate usage (D. Fedje, Parks Canada, *personal communication*).

There is an emerging discussion on uses of traditional information along with western science information within an overarching approach to conservation (Mauro and Hardison 2000). Such an approach should have a role in managing spatial marine conservation in Gwaii Haanas. A way to give respect to this process would be to use indigenous knowledge (and other local experiential knowledge) to make hypotheses that could be scientifically tested and then applied in an adaptive conservation management regime (Sloan 2002). Further, traditional knowledge systems themselves may already possess analogies to the adaptive management approach (Berkes *et al.* 2000).

- **improve regional physical and biological oceanographic knowledge**

Productivity studies of plankton and currents, especially in the nearshore, are crucial. We need to understand the connectivity (energy, nutrients, larvae) between different areas of Haida Gwaii and between inshore and offshore. Currently we have no notion of appropriate scale and linkages for effective marine area conservation, as determined by invertebrate larval source-sink dynamics in the Haida Gwaii region. Where planktonic larvae go and how they survive is key information for the scale of eventual zoning such as location of fishing sites, refugium size and distances between refugia. We also need to identify those species with larvae residing only a short time in the plankton as well as those species with only benthic larvae or no larvae. Oceanography, particularly at smaller than conventional spatial scales, has a core role in understanding recruitment processes leading to spatial patterns in adult populations (Bradbury and Snelgrove 2001). Seasonal plankton phenomena and upwelling events influence local invertebrate well-being in ways we do not understand. This whole topic area is a missing building block for knowing the roles of invertebrates in local marine ecosystems.

- **chart the west coast of Gwaii Haanas**

The west side of Gwaii Haanas north of Nagas Point to Tasu Sound being largely unsurveyed (for depth, substrate type, bottom topography) is not in keeping with the need for long-term, knowledge-based conservation. The only charted area within this coastline is Gowgaia Bay. The west side of Gwaii Haanas is the largest stretch of British Columbia coastline that remains uncharted.

Charting should be done through interagency cooperation led by the Canadian Hydrographic Service (DFO). Without this, we lack core data on the mosaic of habitats (determined by depth, bottom relief and substrate) that would underpin an understanding of benthic invertebrate-habitat relationships and ecosystem function for most of the west coast of Gwaii Haanas.

- **work up Haida Gwaii material in key Canadian museum collections**

Considering just deep-sea benthic invertebrate species, Poore and Wilson (1993) estimated that the ratio of known to total faunas might be as high as 1:20 – which forms part of their world-wide estimate of ≈5 million species. This is bracketed by previous estimates of ≈10 million (Grassle and Maciolek 1992) to ≈500,000 species (May 1992). That the experts should have such wide-ranging estimates reveals the depth of our ignorance! Clearly, there are many more marine invertebrate species out there than are in databases, and the Gwaii Haanas region is no exception.

Possible initiatives are firstly to examine the unsorted/unidentified material as a low-cost way to expand our species biodiversity inventory and secondly to have all the identified material checked by specialists group-by-group. Likely most collections are in museums, but some are maintained by individual specialists and some are in marine stations and universities. Checking identifications is a long-term proposition given the small number (»120) of specialists world-wide with direct interests in Canadian marine life (Austin *et al.* 1997). Moreover, this does not include the description of new taxa found during the checking process. Clearly, support is needed for training both taxonomists and parataxonomists and for the time consuming identification and description processes. Such a systematic assessment must be an international effort for specialists to access the collections.

- **collect in poorly represented habitat types to fill egregious database gaps**

In keeping with the reality that so little has been done in this region, many large gaps in invertebrate species biodiversity knowledge exist. These should be addressed because knowledge about all habitats and ecosystem types will be needed for long-term, ecosystem-based management. A few examples of underrepresented areas in our basic invertebrate biodiversity knowledge are: estuaries (see below), deep-water, rock-dwelling corals and other species not easily sampled by dredges or grabs, the meiofauna (intertidal and subtidal), rocky bottom/kelp forest benthos, highly exposed intertidal shores and continental shelf/slope sediments.

- **focus on invertebrates of estuaries as critical land-sea linkage habitats**

The protected and relatively undisturbed uplands of Gwaii Haanas are a key regional attribute that will enable long-term studies of land-sea interactions on the scale of small coastal watersheds. Estuaries are the spaces where the transition area between terrestrial to marine species biodiversity is the most marked and the most amenable to mapping. Gwaii Haanas estuaries are, however, not well enough understood ecosystems, although they are critical to high-profile salmonid and wildlife (e.g., black bear [*Ursus americanus carlottae*] and shore bird) populations. A vegetation-based classification is currently underway (complimentary to provincial guidelines – Howes *et al.* 1999) and this should be matched by studies of invertebrates associated with the plant communities. A start has been made in that intertidal invertebrates of some estuaries was assessed in 1992 with respect to elevation (Harper *et al.* 1994). Further, the estuarine intertidal is a useful candidate areas towards reconciling the terrestrial-marine conventions for basic elevation data and vertical datum reference levels.

- **start mapping the marine biodiversity of Gwaii Haanas**

Mapping can greatly increase the utility of biodiversity information. Key to spatial management of Gwaii Haanas will be mapping patterns of invertebrate species and communities according to benthic habitats. Invertebrates constitute key components of food webs as they account for ≈90% of the marine animal species. Ideally, we will eventually understand the factors causing those mapped patterns. Future marine invertebrate biodiversity work in this region should, therefore, connect invertebrate species to definable places, habitats and associations. For example, there may be an opportunity to link with the forthcoming multi-agency (DFO, NRCan, National Defense)/ industry/academia Seabed Resource Mapping Program (SeaMap) to map Canada's submerged features (T. Tomascik, Parks Canada, *personal communication*). Marine surveillance technologies are developing rapidly and marine conservation areas could benefit.

- **monitor the marine area using Parks Canada's Warden Service**

Gwaii Haanas should be a reference site for regional marine environment/ecosystem well-being. Wardens spend more time travelling in this isolated region than any other technical agency staff. The Warden Service, with science direction and subsequent evaluation by a multi-agency (Parks Canada, DFO, EC, NRCan) group, could implement marine monitoring. This could be a core science task for the Warden Service and embedded within Gwaii Haanas' long-term operating budgets. At a minimum, wardens would cover the proposed Gwaii Haanas marine conservation area within the whole Haida Gwaii region. The data would be shared through the World Wide Web.

- **commit to long-term ecosystem-based Hecate Strait studies**

A good opportunity is at hand for Gwaii Haanas to help coalesce different interests in the Hecate Strait towards knowledge-based regional marine conservation. Firstly, there is the on-going (since 1982) DFO commitment to multi-species groundfish research (Perry *et al.* 1994); secondly, the sponge bioherm work (Conway *et al.* 2001); thirdly, the oceanographic knowledge (Crawford 2000); fourthly, the geology research of the Queen Charlotte Basin (Woodsworth 1991); and fifthly, benthic invertebrate studies (e.g., Bernard 1979; Burd and Brinkhurst 1987).

Further, Hecate Strait's productive waters will become topical if the oil and gas exploration moratoria are lifted. This would create a pressing need for an altogether better Hecate Strait marine environmental baseline inventory and stimulate more science on the Strait's ecosystem structure and function. Gwaii Haanas should be among the cooperating stakeholders within this key regional marine ecosystem issue.

- **support declaration of the sponge bioherms as DFO Marine Protected Areas**

The sponge bioherm areas of Hecate Strait and Queen Charlotte Sound are an ideal candidate group for area-specific declaration as Marine Protected Areas under DFO's *Oceans Act* mandate. Sufficient science has been published to characterize these unique marine invertebrate-structured areas. In keeping with Parks Canada's broader regional view of marine conservation, we should support declaration of the bioherms' protected status by DFO before further bottom-trawling damage occurs.

- **use shellfish species to help address spatial scale within Gwaii Haanas**

Among the invertebrates, edible species (traditional Haida foods, commercial and recreational) naturally receive more human interest than other marine invertebrates. Therefore, we should wisely use this interest and what we know about these species' life histories (particularly those with spatially explicit adult populations), to initiate discussions on scale and connectedness within Gwaii Haanas. For example, such discussions concerning red sea urchin, geoduck or northern abalone would help delineate zoning networks of connected no-take zones within Gwaii Haanas' future multiple-use matrix. The scale of these spaces should be determined by our knowledge of their connections through larval replenishment processes and the need for having stock available for our commitment to commercial fishing. In other words, setting aside source populations both as examples of local ecosystems and as sources of recruits for sustainable nearby fisheries. However, we should remember that the less well known, non-edible species also receive protection.

- **understand the socioeconomics of Haida Gwaii shellfisheries**

Knowing who pays for and who benefits from marine conservation is essential. Understanding the impacts to communities of marine area conservation is a core component of public consultation (NRC 2001). Our shellfishery overview requires a complimentary study of the social and economic importance of shellfisheries at the individual community, regional and provincial scales. We must listen carefully to the fisheries sector (fishers, processors, associations). Jentoft (1998) emphasizes that social science is usually absent from fisheries management decision-making. Further, agency commitments to public consultation in marine conservation compel us to look deeply into the human consequences of protecting marine spaces. Therefore, Jentoft's two major roles of social science in fisheries; (1) design of management institutions, and (2) provision of feedback to the management process - are important to consider. For example, the impacts to the industry of future marine zoning in Gwaii Haanas, including no-take areas, must be understood if it will be accepted within the public consultation process. Other issues include the ripple effects of sea otter protection within Gwaii Haanas to all regional Haida Gwaii shellfisheries.

- **acquire fishers' experiential knowledge of invertebrates**

Working with fishers to learn from their experiences with invertebrates is a point of engagement for relationship-building, besides an important source of technical information. In the long-term, the fisheries sector must be engaged as a key partner in Gwaii Haanas' future. As an example of their knowledge, finfish long-liners know the locations of deep-water coral groves on current-swept, rocky continental slope areas along the west side of Gwaii Haanas. Fishers were a key information source for inventory of Nova Scotia's deep-water coral groves (Breeze *et al.* 1997). Recognizing the fisheries sector as a participant in the future of Gwaii Haanas is imperative. But, we will need to build trust that the outcomes of their knowledge-sharing will not feed-back negatively on the fisheries economy.

- **federal agencies must cooperate more for marine conservation science progress**

" ... effective application of ecological integrity principles will require collaboration and partnerships among federal science-based departments and agencies, and between the government and its non-federal partners."
(Industry Canada - IC 2000)

A reality-check is warranted because of the size and complexity of the challenge. To begin understanding regional marine ecosystems, all the key federal agencies (Parks Canada, DFO, EC, NRCan) must cooperate more closely than ever and partner with other entities (NGOs, First Nations, universities, fishery sector, coastal communities). Core to such cooperation is DFO - the agency with the most capacity and regional marine science history. The *Oceans Act's* preamble contains a clear DFO commitment to marine ecosystems, as follows:

- *"Canada promotes the understanding of oceans, ocean processes, marine resources and marine ecosystems to foster the sustainable development of the oceans and their resources;"* and

- *"Canada holds that conservation, based on an ecosystem approach, is of fundamental importance to maintaining biological diversity and productivity in the marine environment."*

Accordingly, DFO should, in addressing its *Oceans Act* mandate, return part of its science thrust to its roots in basic ecological and biodiversity research. That means building upon overlooked traditions of the Pacific Biological Station's basic research in the Haida Gwaii region (e.g., C.M. Fraser in the 1930s and D.B. Quayle and F.R. Bernard in the 1950s to 1970s) and integrating that ethic with the capacity of the Institute of Ocean Sciences, Sidney (e.g., Thomson 1989; Crawford 2000). An enlightened research commitment, beyond stock assessment into fundamental issues of marine biodiversity and ecosystem structure and function, is needed.

Fishing is central to the long-term future of Gwaii Haanas. To enable ecosystem-based management of human activities, there must be access to the full information base for the management partnership. This means access to both fishery-dependent and fishery-independent data with attendant confidentiality to protect the interests of individual fishers and maintain trust among the partners. An example is finding the balance between serving the public good with access to information on continental shelf bottom trawl tracks and serving the industry good by protecting appropriate portions of such data. All information sources are relevant and all should be shared. The strategic step of partners' consensus on information policy would solidify future working relationships.

- **increase public awareness and understanding of marine invertebrates and associated habitats**

Awareness and understanding are key to fostering stewardship and support for marine conservation. Agencies such as DFO and Parks Canada must continue to work with NGOs that promote marine conservation. Also, government agencies mounting their own initiatives should ensure that these compliment, not overshadow, NGO efforts.

Both NGOs and government organizations should collaborate in working with the media to promote awareness and understanding through magazines such as Canadian Geographic, Beautiful British Columbia, television documentary programs such as Discovery Channel, Knowledge Network, newspapers and even stamps (e.g., the Canada Post "Canadian corals" stamp to be issued in 2002).

The NGOs played a key role in the establishment of Gwaii Haanas National Park Reserve / Haida Heritage Site. Particularly in a remote region such as Haida Gwaii, NGO support must be nurtured and acknowledged. The remoteness of Haida Gwaii limits the number of people who can directly experience its marine ecosystems. However, most of the same species and habitats occur in more accessible regions of southern British Columbia. Experiential programs in the field (e.g., DFO Shorekeepers, Hecate Strait Streamkeepers, Laskeek Bay Conservation Society, Haida Gwaii Marine Resources Group Association, Georgia Strait Alliance Straitkeepers), entities explicitly promoting marine conservation (e.g., World Wildlife Fund-Canada Marine Program, Living Oceans Society, Sierra Club, David Suzuki Foundation, Canadian Parks and Wilderness Society), and coastal facilities (e.g., Bamfield Marine Station, Marine Ecology Station, Vancouver Aquarium) foster understanding and participation in marine conservation coast-wide.

- **increase science cooperation with Naikoon Provincial Park**

Gwaii Haanas represents the rocky shores of Haida Gwaii well, but not the sandy shores typical of Naikoon Provincial Park within the Queen Charlotte Lowlands (the Argonaut Plain) in the archipelago's northeast corner (Figure 1). Although the province of British Columbia has had an important role in the establishment of Gwaii Haanas (e.g., the *South Moresby Agreement* [1988] and the transfer of jurisdiction of the proposed marine area's seabed [2001]), Parks Canada has been little involved with Naikoon. This is not in keeping with the spirit of Parks Canada's marine policy of regional concern outside park boundaries and given the inherent ecosystem value, and invertebrate populations, of Naikoon's incomparable sandy beaches.

Naikoon Provincial Park was established in 1973 and is managed by British Columbia Parks (under the *British Columbia Park Act*) within the British Columbia Ministry of Water, Land and Air Protection. The park protects the relatively level, boggy coastal forests on glacial deposits and marine-derived sand dune systems. Naikoon has ≈724 km^2 of land and ≈108 km of mostly sandy shoreline comprising ≈2.16 km^2 of park "foreshore" – an intertidal band whose width is ≈200 m seaward of the high tide line. Naikoon has no subtidal marine area, i.e., no sea space. With the exception of two rocky promontories (Yakan Point and Tow Hill), the shoreline consists almost entirely of sand beaches exposed to high wave energy. There is some cobble-boulder shoreline near Tlell in the park's southeastern corner.

Naikoon's sand beaches are Pacific Canada's largest and most dramatic. North and South Beaches represent ≈21 km and ≈12 km respectively of continuous sand beaches (≈1 km wide intertidal zone) facing northward into McIntyre Bay, Dixon Entrance. The sands come from offshore and their net onshore movement is speculated to be due to recent uplift of the offshore platform (Harper 1980). East Beach, facing eastward into northern Hecate Strait, extends south from Rose Point as a continuous sandy shore for ≈75 km before merging into the cobble-boulder shoreline near Tlell. The intertidal of East Beach is narrower (<0.5 km) and tends to have more cobble in the lower intertidal than South and North Beaches. For comparison, Long Beach, Wickaninnish Bay within the Long Beach unit of Pacific Rim National Park is ≈11.4 km long and the unit's other major sand beach (in Florencia Bay) is ≈6.4 km long. North Beach and Naikoon's offshore sandy areas are the centre of Haida Gwaii's razor clam and Dungeness crab fisheries.

Naikoon has a year-round staff of one and one seasonal (four-month) ranger. Gwaii Haanas has ≈40 year-round staff. Naikoon is less funded than Gwaii Haanas and it relies on remote technical services, such as GIS, from an off-island British Columbia Parks regional office (in Smithers). Naikoon management performs a science permitting process particularly aimed at the park's two Ecological Reserves (Tow Hill and Rose Spit), but the park has no sustained internal science process in support of management. Ecological Reserves are separately managed by British Columbia Parks under the *Ecological*

Reserves Act. Given the complementation of Gwaii Haanas' rocky shores and Naikoon's sandy shores within Haida Gwaii, there should be more regional ecosystem-based, technical cooperation between these coastal parks.

EPILOGUE

Clark (1993) called current conservation professionals: "…. *the last generation that can prevent the extinction of large numbers of species and the disruption of large scale ecosystem processes.*" In other words, this is the time to act. It is acknowledged world-wide, however, that marine conservation lags behind terrestrial conservation technically, intellectually and politically (NRC 2001).

The Gwaii Haanas marine area is being considered during the most exciting and dynamic era in marine conservation history. Tremendous advances in computer-based tools for marine map and database processing are on-going. Fundamental technical and political progress is being made in the United States on conserving marine spaces (NRC 2001). Canadian agencies (EC – Zurbrigg 1996; interagency – Anonymous 1998; DFO – Jamieson and Levings 2001) and environmental NGOs (Day and Roff 2000; Wallace and Boyd 2000) are also embracing habitat- and ecosystem-based ideas for conserving marine spaces. As well, there are many recent, science-based books for the lay public underscoring that fundamental change is needed in human-ocean relations based upon fisheries' spectacular failures and negative ecosystem effects (Earl 1995; Berrill 1997; Safina 1997; Harris 1999; Dobbs 2000; Glavin 2000; Woodward 2000; Helvarg 2001).

Invertebrates are vital to assembling the information tools for future marine conservation. However, science moves too slowly for the critical near-term decision-making we need. We need the wisdom of a precautionary approach to offset uncertainties and the flexibility of adaptive management to chart our course. We need vision to fulfil Gwaii Haanas' promise through new partnerships and forthcoming public consultation. Finally, we need to be humble but bold in confronting our ignorance as we prepare Gwaii Haanas for unborn generations to use, enjoy and cherish.

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Appendix A.

Museums Contacted in the Preparation of this Report
[not all records obtained were used in this report]

Collections in Canada

Royal British Columbia Museum (RBCM)
Phil Lambert, Curator of Invertebrates, Natural History Section
675 Belleville Street, Victoria, BC, V8W 9W2
Phone: 250-387-6513; email: plambert@royalbcmuseum.bc.ca
Internet accessible database: http://rbcm2.rbcm.gov.bc.ca:9000/cgi bin/obj
4861 records were obtained by service contract and online database search.

Canadian Museum of Nature (CMN)
Peter Frank, Chief Registrar and Dr. Jean-Marc Gagnon, Collection Manager - Invertebrates
PO Box 3443 Station D, Ottawa, ON, K1P 6P4
Phone: 613-364-4089; email: pfrank@mus-nature.ca
1855 records were obtained by service contract.

Royal Ontario Museum (ROM)
Don Stacey, Invertebrates Technician and Dr. Dale Calder, Curator of Invertebrates
Centre for Biodiversity and Conservation, 100 Queens Park, Don Street, Toronto, ON, M5S 2C6
Phone: 416-586-8042; email: dons@rom.on.ca
6555 records obtained by service contract.

Redpath Museum, McGill University
Dr. Henry Reiswig, Curator of Sponges, 859 Sherbrooke St. W., Montréal, Québec H3A 2K6
Phone: 514-398-4086 ext. 4089; email: cxhr@musica.mcgill.ca
Contacted, no records obtained.

Pacific Biological Station
Dr. Z. "Bob" Kabata, DFO-Science Branch, Nanaimo, BC, V9R 5K6
Phone: 250-756-7045; email: zkabata@home.com
No records were obtained in response to our inquiry (they have parasite specimens only, invertebrates are sent to RBCM).

Atlantic Reference Centre
Lou Van Guelpen, ARC Collection Manager, Huntsman Marine Science Centre
1 Lower Campus Road, St. Andrews, NB, E5B 2L7
Phone: 506-529-1200; emial: arc@mar.dfo-mpo.gc.ca
No records were obtained in response to our inquiry.

Bamfield Marine Station
Dr. Andre Martel, Assistant Director, Bamfield Marine Station, Bamfield, BC, V0R 1B0
Phone: 250-728-3301; email: amartel@bms.bc.ca
No records were obtained in response to our inquiry.

2

Collections in the United States

US National Museum of Natural History (NMNH), Smithsonian Institution,
Cynthia Ahearn, MRC-163, Department of Invertebrate Zoology
National Museum of Natural History, Smithsonian Institution
Washington DC, 20560-0163
phone 202-786-2125; email: ahearn.cynthia@nmnh.si.edu

Several hundred records were obtained in response to our inquiry.

California Academy of Sciences (CAS)
Dr. Rich Mooi, Chairman and Curator, Department of Invertebrate Zoology & Geology
California Academy of Sciences, Golden Gate Park, San Francisco, CA, 94118-4599
Phone: 415-750-7086; email: rmooi@calacademy.org

850 records were obtained in response to our inquiry.

San Diego Natural History Museum
Dr. Paisley S. Cato, Curator of Collections
PO Box 121390, San Diego, CA, 92112
Phone: 619-232-382 ext. 226; email: pcato@sdnhm.org

No records were obtained as the collection is not on a database.

University of California Museum of Paleontology (UCMP)
1101 VLSB Berkeley, CA, 94720
Internet database: http://www.ucmp.berkeley.edu/collections/invert.html

2 records were obtained from an internet search.

Peabody Museum of Natural History (YPM)
P.O. Box 208118 - 170 Whitney Avenue, Yale University, New Haven, CT 06520-8118
Internet database: http://www.peabody.yale.edu/collections/iz/

17 records were obtained from an internet search.

Harvard Museum of Comparative Zoology (MCZ)
26 Oxford Street Cambridge, MA 02138 phone 617-495-3045
Internet database: http://www.mcz.harvard.edu/Departments/InvertZoo/collections.htm

11 records were obtained from an internet search.

Field Museum of Natural History (FMNH)
Roosevelt Road at Lake Shore Drive, Chicago, IL, 60605
Internet database (molluscs only): http://fm1.fmnh.org/collections/search.cgi?dest=inverts

2 records were obtained from an internet search. There were several other geographically indeterminate records for British Columbia that were not used.

Florida Museum of Natural History (FLMNH)
Division of Malacology, University of Florida
Gainsville, FL, 32611-7800
Internet database: http://www.flmnh.ufl.edu/natsci/malacology/malacology.htm

A single record for Haida Gwaii and several geographically indeterminate records for British Columbia (not used in this study) were obtained.

LA County Museum of Natural History (LACM)
900 Exposition Boulevard, Los Angeles, CA 90006, USA
Lindsey T. Groves, Collection Manager, Malacology & Invertebrate Paleontology
Phone: 213-763-3376; email: lgroves@nhm.org
283 records were obtained in response to our inquiry.
George E. Davis, Collections Manager - Crustacea,
Phone: 213-763-3450; email: gdavis@nhm.org
No records were obtained in response to our inquiry.
Leslie Harris, Annelid Collection
Phone: 213-763-3234; email: lharris@nrm.org
No records were obtained in response to our inquiry.

Academy of Natural Sciences of Philadelphia (ANSP)
Charlene Fricker, Collection Manager, Department of Malacology
1900 Benjamin Franklin Parkway, Philadelphia, PA 19103-1195
Phone: 215-299-1136; email: fricker@acnatsci.org,
http://www.acnatsci.org
2 records obtained from an internet search combined with a follow-up enquiry.

University of Colorado Museum
Rosanne Humphrey, Collection Manager, Zoology Section,
Campus Box 315, Boulder, CO 80309-0315
Phone: 303-492-0276; humphrey@spot.colorado.edu
No records were obtained in response to our inquiry.

Texas Natural History Collections
Texas Memorial Museum, University of Texas at Austin
No records were obtained from an internet search of the specimens database.

Carnegie Museum of Natural History
Robert L Davidson, Section of Invertebrate Zoology
4400 Forbes Avenue, Pittsburgh, PA, 15213
Phone: 412-622-3259; email: davidson@clpgh.org
No records were obtained in response to an inquiry.

Scripps Institution of Oceanography
Lawrence L. Lovell, Museum Scientist, Benthic Invertebrate Collection
9500 Gilman Drive, Mail Code 0244, La Jolla, California 92093-0244
Phone: 858-822-2818; email: llovell@ucsd.edu
No records were located in response to an inquiry.

Collections Outside North America with Haida Gwaii Material

Natural History Museum, London, England
Museum of New Zealand Te Papa Tongarewa (Wellington, New Zealand)
Zoological Institute and Museum, Academy of Sciences, St Petersburg, Leningrad, Russia
University of Copenhagen Museums of Natural History (Copenhagen, Denmark)
Muséum National d'Histoire Naturelle (Paris, France)

Appendix B.

The Attributes of each Element Table in the Working Database

Element Table	Attribute Name	Description of Attribute Properties
Sources	Source_ID	**Unique Number** – each original source (bibliographic citation or collection) has a number
	Citation	The complete bibliographic citation of the source
Sites	Site_ID	**Unique Number** – each site has it's own number
	Source_ID	A number that links to the *Sources* table
	OriginalSite	The site identifier (e.g., number, name, code) from the original source, if it exists
	OriginalLatitude	Latitude as originally recorded or as recorded by us from original notes
	OriginalLongitude	Longitude as originally recorded or as recorded by us from original notes
	AdjustedLatitude	Adjusted latitude if incorrect, e.g. if site turns out to be on land; repositioning was based upon text description of the site, or any other information permitting a common-sense repositioning
	AdjustedLongitude	Adjusted longitude if incorrect, e.g., if site was on land – see above
	HorizontalDatum	North American Datum (NAD) 1927 or 1983, if known
	LocationDescribed	Text describing site, if available
	EstimatedAccuracy	An estimate (in metres) of accuracy of the site's location
	ObservationDate	Date (yyyy/mm/dd) on which observation was taken, or the first date of a date range
	DateRange	Date (yyyy/mm/dd) on which the last observation was taken within a date range
	Depth	Estimated depth (m) at which observation was taken, or the upper depth of the sampling range
	DepthRange	Lower depth only of the sampling range
	Type	Ecological notes on observation site: benthic / intertidal / subtidal / river-estuary / pelagic / parasite / fish stomach / bird stomach / crab stomach
	Comments	Notes on ecological traits of the site, e.g., sea grass meadow, sea urchin barrens, sponges in cave, SCUBA diving, etc.
Observations	Obs_ID	**Unique Number** - uniquely identifies each observation
	Site	Together with Code, these form a **Unique Alphanumeric Code** - links to *Sites* table
	Code	Together with Site, these form a **Unique Alphanumeric Code** - links to *Species* table
	Reliability	A number on our scale of 1 to 5 as follows: 1. Species for which the type specimen(s) come from the Haida Gwaii region 2. Species for which there are other museum specimens; 3. Species mentioned in internationally peer-reviewed and historical publications; 4. Species mentioned in "grey" literature reports and unpublished surveys; and 5. Species observations for which there are known or suspected problems.

Element Table	Attribute Name	Description of Attribute Properties
Specimens	Observation_ID	**Unique Number** – links to the *Observations* table
	Collection	The acronym of the institution in which the specimen(s) is held
	Catalogue	Museum's catalogue number for that specimen
	Accession	Museum's accession number for that specimen
	Lot	Museum's lot number for that specimen
	TypeStatus	Type status of the specimen, e.g., paratype, holotype, etc.
	OtherSources	Number(s) identifying other sources relating to that specimen(s)
	Number	Number of specimens of that taxon
	Notes	Miscellaneous text on specimens, e.g., gender, reproductive state, unpublished record
Haida Names	Code	**Unique Alphanumeric Code** - links to the *Species* table
	HaidaName	The Haida language name (spelling/orthography) according to the Skidegate Haida Language Authority, Skidegate Haida Immersion Program (SHIP)
	OrthographyNotes	Notes on the orthography used because some databases cannot accommodate (recognize) the orthographic symbols selected by SHIP
	Notes	Text on interpretation of the Haida name, e.g., shrimp name derived from "to run backwards"
Species	Code	**Unique Alphanumeric Code** – our in-house code for linking to other tables
	Genus	Genus name and a link to the *Genera* table
	Species	Specific epithet
	Subspecies	Sub-specific epithet
	Taxon	Full species name
	Authority	The name of the original describer of the species and the date when published, if available
	CommonName	Most-used common name (subjective)
	OtherCommonNames	Other common names from the literature
	Comments	Miscellaneous text on whether the identification is questionable and ecological notes, e.g., parasite, rarity, seagrass meadow, etc.
Genera	Family	Family name and a link to the *Families* table
	Subfamily	Subfamily name, if it exists
	Tribe	Tribe name, if it exists
	Genus	**Unique Name** – *genus* name consistent with the *International Code of Zoological Nomenclature* (ICZN)
	Authority	The name of the original describer of the genus and the date when published, if available
	CommonName	Most-used common *genus* name (subjective)
Families	Order	Order name and a link to the *Orders* table
	Suborder	Suborder name, if it exists
	Infraorder	Infraorder name, if it exists
	Superfamily	Superfamily name, if it exists
	Family	**Unique Name** – family name consistent with to the ICZN
	Authority	The name of the original describer of the family and the date when published, if available
	CommonName	Most-used common family name (subjective)

Element Table	Attribute Name	Description of Attribute Properties
Orders	Class	Class name and a link to the *Classes* table
	Subclass	Subclass name, if it exists
	Superorder	Superorder name, if it exists
	Order	**Unique Name** – order name consistent with the ICZN
	Authority	The name of the original describer of the order and the date when published, if available
	CommonName	Most-used common order name (subjective)
Classes	Phylum	Phylum name and a link to the *Phyla* table
	Subphylum	Subphylum name, if it exists
	Superclass	Superclass name, if it exists
	Class	**Unique Name** – class name consistent with the ICZN
	Authority	The name of the original describer of the class and the date when published, if available
	CommonName	Most-used common class name (subjective)
Phyla	Phylum	**Unique Name** – phylum name consistent with the ICZN
	CommonName	Most-used common phylum name (subjective)
	Index	A phylum's number indicating approximate phylogenetic order, e.g., the sponges (Porifera) are 1 and the acorn worms (Hemichordata) are 23

Appendix C.

Haida Names of Marine Invertebrates

[Data are courtesy of the Skidegate Haida Language Authority (Skidegate Haida Immersion Program), Blackman (1979), and Ellis and Wilson (1981)]

Common name (*scientific name*)	Skidegate Haida Language Authority[1]		Ellis and Wilson (1981)		Blackman (1979)[2]	
	Skidegate Haida name	Notes on derivation	Skidegate Haida name	Notes on derivation	Northern Haida Name	Notes on derivation
Coelenterates						
Jellyfish [with tentacles] (*Chrysaora/Cyanea/Aurelia* spp.)	kiiyang.g̱a		k'iiyáang-ga	"poison seafood"		
Jellyfish [without tentacles] (species unknown)	g̱aay ts'aa7uldang		gàayuu ts'aa7ùldàang	"blink in the open sea"		
By-the-wind-sailor (*Valella valella*)	sḵiihl ts'il		sḵìilh ts'ìl	"black cods' dorsal fin"		
Green sea anemone (*Anthopleura* spp.)	s7iip		s7ìip	"anything big and round"		
Red sea anemone (*Urticina* spp.)	x̱ang.a sg̱iidang		x̱ànga sg̱iidàng	"red face"		
Molluscs						
Northern abalone (*Haliotis kamtschatkana*)	g̱aalahlyan g̱aalg̱ahlyan g̱alg̱uuhlkyan g̱aalahx̱yan g̱alg̱ahlyan g̱aal7uhlyan	(A. Yovanovich & N. Young) (E. Wilson) (K. Hans Sr.) (R. Jones) (S. Wilson) (W. Price)	gàlgalh iiyàan	"abalone"	gəlgiłyEn	
Red abalone (Haliotis rufescens)	gulx̱a		gwùlx̱a	"California abalone"		

Common name (*scientific name*)	Skidegate Haida Language Authority[1]		Ellis and Wilson (1981)		Blackman (1979)[2]	
	Skidegate Haida name	Notes on derivation	Skidegate Haida name	Notes on derivation	Northern Haida Name	Notes on derivation
Small gastropods (*Littorina/Calliostoma/Fusitriton* spp.)	skaay		skay	"small shells"	sq'owii	
Moon snail (*Polinices lewisii*)	st'aaw, gyuudan		st'àaw, gyùudan		giudan	
Limpets (*Acmaea/Collisella/Notoacmea/Diodora* spp.)	sk̲aats'ixuu		sk̲àats'ixwuu	"perhaps from black oyster catcher"	yEłd'ajang-a	
Red turban snail (*Astraea gibberosa*)	gwaahlgiidang k̲'al		gwàalh giidang k̲àal	"round"	sq'owii	
California mussel (*Mytilus californianus*)	taax̲aaw		s7iits'aang tàax̲àaw sg̲wùns sk'àax̲àaw	"sweet food - immature" "sweet food - common size" "sweet food - large size "	taoó	
Blue mussel (*Mytilus trossulus*)	s7iits'aan g̲al	small mussel full grown	s7iits'aang g̲al	"immature" "common size"	həəl	
Purple-hinged rock scallop (*Crassadoma gigantea*)	lhk̲'wii		lhk̲w'ii	"rock oyster"	q'olinł q'aja	"super strong"
Weathervane scallop (*Patinopecten caurinus*)	gaabuu		gaabúu	"anything flat and thin at one end"	gəbé	
Nuttall's cockle (*Clinocardium nuttallii*)	sg̲yaal		sgyàal		skiÉl	
Clam	k'yuu					
Butter clam (*Saxidomus gigantea*)	k̲aaga / k'yuu		ky'uu		k'iu	
Native littleneck clam (*Protothaca staminea*)	k̲'aaga		k̲àaga, ky'uu		q'aaka	
Bent-nosed clam (*Macoma nasuta*)	k'yuu		ky'uu			
Razor clam (*Siliqua patula*)	k̲'aamahl		k̲'àamalh		q'aməl	

Common name (*scientific name*)	Skidegate Haida Language Authority[1]		Ellis and Wilson (1981)		Blackman (1979)[2]	
	Skidegate Haida name	Notes on derivation	Skidegate Haida name	Notes on derivation	Northern Haida Name	Notes on derivation
Horse clams/shell (*Tresus capax / Tresus nuttallii*)	7uwanga / k'aal		sk̲aaw		sq'au	
Geoduck clam/shell (*Panope abrupta*)	sk̲aaw / sk'aawal		stan	"anything round and soft"		
Piddock [boring clam] (*Zirphaea pilsbryi*)	k̲'aas		k̲'aas	"clay borers"		
Jingle shell (*Pododesmus macrochisma*)	stl'ing gudgaa k̲'aal		stl'èn gwuutgaa k̲àal	"empty at the bottom"		
Toredo [wood-boring "shipworm"] (*Bankia setacea*)	daaga		dàaga			
Octopus (*Enteroctopus dofleini*)	naaw		naw	"devil fish"	nu	
Gumboot chiton (*Cryptochiton stelleri*)	sgiida	red chiton	sgìidaa	"large red Chinese slippers"	s° it	
Black katy chiton (*Katharina tunicata*)	t'aa	small black chiton	t'aa	"small Chinese slippers"	t'a	
Unidentified chitons (species unknown)	sdllguu t'àagaa		sdèlguu t'àagaa, x̲wùuya t'àagaa	"land otter's or raven's chitons"		
Tusk shell (*Antalis pretiosum*)	guu ts'ing		gwuu ts'ìng	"money tusk"		
Annelids						
Vermiform animals [worms] (e.g., *Nereis vexillosa*)	siiga		sìiga	"anything that wiggles"		
Crustaceans						
Barnacles (*Balanus* spp.)	gawduuwal		gàaw		xau t'woun	"giant barnacle"
Goose barnacle (*Pollicipes polymerus*)	tl'k'yaaw		tl'èlky'àaw	"gumboots"		

Common name (*scientific name*)	Skidegate Haida Language Authority[1]		Ellis and Wilson (1981)		Blackman (1979)[2]	
	Skidegate Haida name	Notes on derivation	Skidegate Haida name	Notes on derivation	Northern Haida Name	Notes on derivation
Pelagic goose barnacle (*Lepas anatifera*)	chaag̲an tl’k’iiwaay		tsaagàn tl’èlky’àaw	“deep-water goose barnacle”		
Crab	k̲’uust’an				ch’aam	“rock crab”
Dungeness crab (*Cancer magister*)	k̲’uust’an		k̲w’uust’àan	“to bite”	qostan	
Red king crab (*Paralithodes camtschatica*)	huuga		huuga	“spider crab”		
Box crab (*Lopholithodes mandtii*)	daawxuusda huugagaay		daawxwùusta huuga gaay	“west coast king crab”		
Purple shore crab (*Hemigrapusu nudus*)	ts’àa7am		ts’àa7am	“crossed”		
Spider Crab (*Pugettia* spp.)	huuga					
Hermit crab (*Pagurus* spp.)	ts’ aa7am skaay		ts’ àa7am skay	“shell crab”		
Pea crab (*Fabia* spp., *Pinnotheres* spp.)	giidgaay		gìitgay	“baby”		
Shrimps (*Pandalus* spp.)	guudaa gii gaayd gudga gii gaayd gudgat gii gaayd	Shrimp or prawn	gwùutga gigàyt	“to run backwards”	d’ɨg^{a}	
Amphipod	kun t’axwang *or* kun t’axuung	Beach hopper (intertidal amphipod)	kwùn t’axwùng			
Cyamid Amphipod	daga	Sea lice (deep-water amphipod)				
Euphausiids [krill] (*Euphasia pacifica*)	chiitaaw		tsii tàw	“red feed / pink feed”		
Echinoderms						
Sea cucumber (*Parastichopus californicus*)	giinuu		gìinuu			
Red sea urchin (*Strongylocentrotus franciscanus*)	guuding.aay		gùudìingay	“large sea egg”	s-t’u	

Common name (*scientific name*)	Skidegate Haida Language Authority[1]		Ellis and Wilson (1981)		Blackman (1979)[2]	
	Skidegate Haida name	Notes on derivation	Skidegate Haida name	Notes on derivation	Northern Haida Name	Notes on derivation
Green sea urchin (*Strongylocentrotus droebachiensis*)	styuu kamdala		styuu	"small sea egg"		
Purple sea urchin (*Strongylocentrotus purpuratus*)	daaws stiiway, styuu x̲aassa		dàaw stiiway, styuu x̲aasàa	"west coast or dark sea urchin"	s-t'u	
Sea star	sk'aa 7um					
Sunflower seastar (*Pycnopodia helianthoides*)	naaw k̲'aanaasga		nàw k̲aanàasga	"octopus's friend"		
Purple seastar (*Pisaster ochreceus*)	sk'aa7um		sk'àa7àm	"crossed"		
Sand dollar (*Dendraster excentricus*)	k̲'uulu gaagang̲ii		k̲w'uulùu gaagàngii	"knee cap'		
Tunicates						
Hairy sea squirt (*Halocynthia hilgendorfi*)	k̲'uuskaatl'		k̲w'uuskày tl'el	"tiny bite"		

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[1] Current to April, 2001

[2] In the absence of a standard orthography for Masset Haida dialect, Blackman (1979) used a modified version of the international phonetic alphabet in her spellings. A glossary of symbols was appended to her paper.

Appendix D

Marine Invertebrate Species Recorded from the Haida Gwaii Region

Authorities are provided for species and sub-species designation only. Sub-genera are not designated.

Museum acronyms are as follows:

ANSP = Academy of Natural Sciences of Philadelphia
CAS = California Academy of Sciences
CMN = Canadian Museum of Nature
ERIC = Agricultural Canada Insect Collection
FLMNH = Florida Museum of Natural History
FMNH = Field Museum of Natural History
LACM = Los Angeles County Museum of Natural History
MCZ = Museum of Comparative Zoology, Harvard University
NMNZ = National Museum of New Zealand
OSU = Oregon State University
RBCM = Royal British Columbia Museum
ROM = Royal Ontario Museum
Russia = unknown collection in Russia
SU = Stanford University
USNM = U.S. National Museum of Natural History, Smithsonian Institution
YPM = Peabody Museum, Yale University

Notes on abbreviations and symbols used:

sp.	refers to a single sppecies because in the vast majority of cases this likely represents just one species although there may be multiple specimens.
cf.	means species is unknown or new, but comparable with ...
aff.	means does not quite resemble but is close to ...
species A	means an undescribed species
*	denotes species introduced to the Haida Gwaii region (n=15)
underline	denotes type specimen(s) (n=99)
bold	denotes red-listed (extirpated / endangered / threatened) and blue-listed (vulnerable) at the regional Conservation Data Centre, Victoria, B.C. (n=16)
unk	means that the species authority is unknown, and could not be traced (n=14)
?	means that the species identification is unconfirmed or questionable (n=42)

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Taxon	Observations Recorded	Museum Collections	References in Appendix E
Phylum Porifera (Sponges)			
Class Calcarea			
Subclass Calcinea			
Order Clathrinida			
Family Clathrinidae			
Clathrina sp.	1		12
Subclass Calcaronea			
Order Leucosoleniida			
Family Leucosoleniidae			
Leucosolenia sp.	2		23, 65
Leucosolenia eleanor Urban, 1905	19	RBCM	8, 9, 10, 11, 12, 13, 14, 16, 22, 160
Leucosolenia nautilia de Laubenfels, 1930	2		10
Leucosolenia cf. *tenera* Tanita, 1940	1		8
Order Sycettida			
Family Amphoriscidae			
Leucilla nuttingi (Urban, 1902)	4		12, 13, 160
Family Grantiidae			
?Grantia sp.	1		11
Leucandra sp.	12	CMN	8, 9, 23, 160
Leucandra heathi Urban, 1905	11		276
Leucopsila cf. *stylifera* (Schimdt, 1870)	1		25
Leucandra cf. *taylori* Lambe, 1900	1		8
Family Heteropidae			
Heteropia cf. *striata* Hozawa, 1916	1		25
Family Sycettidae			
Scypha sp.	7	RBCM, ROM	9, 11, 16, 98, 160
?Scypha ciliata Fabricius, 1780	1		305
Scypha mundula (Lambe, 1893)	1		8
Scypha raphanus Schmidt, 1862	1	RBCM	
Tenthrenodes sp.	1		10
Class Hexactinellida			
Subclass Amphidiscophora			
Order Amphidiscophora			
Family Hyalonematidae			
Hyalonema sp.	1		24
Hyalonema populiferum Schultz, 1899	1		25
Subclass Hexasterophora			
Order Lyssacinosa			
Family Rossellidae			
Acanthascus platei Schulze, 1899	8		23
Rhabdocalyptus dawsoni (Lambe, 1892)	17	CMN, RBCM	22, 23
Staurocalyptus dowlingi Lambe, 1893	11	CMN, RBCM	23
Staurocalyptus solidus Schultz, 1899	1		15

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Order Hexactinosa			
Suborder Clavularia			
Family Farreidae			
Farrea occa Bowerbank, 1862	14		17, 23
Suborder Scopularia			
Family Aphrocallistidae			
Aphrocallistes sp.	1	USNM	
Aphrocallistes vastus Schulze, 1887	24	CMN, RBCM	8, 23
Family Euretidae			
Chonelasma calyx Schulze, 1887	15	RBCM	23
Class Demospongiae			
Subclass Tetractinomorpha			
Order Choristida			
Family Geodiidae			
Geodia mesotriaena Lendenfeld, 1910	9	CMN, RBCM	204
Geodinella robusta Lendenfeld, 1910	3	CMN	23
Pachymatisma johnstonia Bowerbank, 1842	1	CMN	
Family Pachastrellidae			
Pachastrellidae	1		23
Poecillastra sp.	2		22
Poecillastra japonica Bowerbank,1866	9	CMN, RBCM	22, 23
Family Stellettidae			
Penares cortius de Laubenfels, 1930	1	RBCM	
Stelleta clarella de Laubenfels, 1930	12	RBCM	8, 10, 12, 13, 20, 160
Order Spirophorida			
Family Tetillidae			
Craniella arb (de Laubenfels, 1930)	5	CMN, RBCM	8, 9, 205
Craniella spinosa Lambe, 1893	1		8
Craniella villosa Lambe, 1893	5	CMN, RBCM	160, 204, 205
Order Hadromerida			
Family Clionidae			
Cliona sp.	20	RBCM	8, 10, 13, 20, 22, 160
Cliona celata Grant, 1826	4		297, 298
Family Polymastiidae			
Polymastia sp.	2	RBCM	23
Polymastia pachymastia de Laubenfels, 1932	3	RBCM	8, 9
Polymastia pacifica Lambe, 1893	2	RBCM	10
Family Suberitidae			
Laxosuberites sp.	1		160
Pseudosuberites sp.	4	RBCM	23
Suberites sp.	18	RBCM	8, 9, 16, 20, 259
Suberites species A	5		160
Suberites domuncula forma *latus* Lambe, 1893	27	CMN, RBCM	8, 9, 10, 18, 20, 193
Suberites montiniger Carter, 1880	1		8
?*Suberites simplex* (Carter, 1876)	2		23

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Tethyidae			
Tethya californiana (de Laubenfels, 1932)	11	RBCM	8, 9, 20, 160, 276, 305
Order Axinellida			
Family Axinellidae			
Auletta sp.	3		8, 22, 23
Axinella sp.	8	CMN, RBCM	10, 23
Pseudaxinella sp.	2	RBCM	10
Stylissa stipitata de Laubenfels, 1961	2	RBCM	10
Syringella amphispicula de Laubenfels, 1961	1		25
Family Raspailiidae			
Hemectyon sp.	2	RBCM	
Hemectyon hyle de Laubenfels, 1930	1		8
Subclass Ceractinomorpha			
Order Halichondriida			
Family Halichondriidae			
Halichondria sp.	2		8, 268
Halichondria cf. *bowerbanki* Burton, 1930	2		10
Halichondria panicea (Pallas, 1766)	47	CMN, RBCM	8, 9, 10, 12, 160, 204, 276, 297
Topsentia disparilis (Lambe, 1894)	4		23
Family Hymeniacidonidae			
Hymeniacidon sp.	1		160
Hymeniacidon cf. *assimilis* Levinsen, 1886	1		23
Order Poecilosclerida			
Family Amphilectidae			
Biemna cf. *megalosigma* Hentschel, 1912	1		23
Biemna rhadia de Laubenfels, 1930	1		23
Family Anchinoidae			
Podotuberculum hoffmanni Bakus, 1966	4	CMN	11, 15
Family Cladorhizidae			
Asbestopluma sp.	1		17
Asbestopluma occidentalis (Lambe, 1893)	2		23
Family Clathriidae			
Anthoarcuata graceae Bakus, 1966	1	RBCM	
Microciona primitiva Koltun, 1955	2	CMN, ROM	98
Ophlitaspongia pennata (Lambe, 1895)	37		8, 10, 12, 160, 268, 276, 297, 298
Family Esperiopsidae			
Neoesperiopsis sp.	2	RBCM	22
Neoesperiopsis digitata (Miklucho-maclay, 1870)	10	CMN, RBCM	10, 16, 20, 204
Neoesperiopsis rigida (Lambe, 1893)	3	RBCM	9, 12
Neoesperiopsis vancouverensis (Lambe, 1892)	1	RBCM	
Family Mycalidae			
Desmacella cf. *vestibularis* (Wilson, 1904)	1		23
Mycale sp.	1		22
Mycale adhaerens Lambe, 1893	7		276
Mycale bellabellensis Lambe, 1905	3		23
Mycale loveni (Fristedt, 1887)	3	CMN, RBCM	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Mycale macginitiei de Laubenfels, 1930	2	CMN	8
Family Myxillidae			
Acarnus erithaceus de Laubenfels, 1927	6		9, 10, 16, 160, 237
Acarnus cf. erithaceus de Laubenfels, 1927	1		23
Anaata spongigartina de Laubenfels, 1930	1		8
Iophon chelifer Ridley & Dendy, 1886	1	RBCM	
Iophon chelifer var. *californiana* Ridley & Dendy, 1886	2	RBCM	
Iophon pattersoni Bowerbank, 1866	4	CMN	23
Jones amaknakensis (Lambe, 1895)	2	CMN, RBCM	
Lissodendoryx sp.	1		8
Lissodendoryx firma Lambe, 1894	2		8
Merriamum sp.	1		23
Merriamum aff. *Lissodendoryx ivanovi* Koltun, 1958	1		15
Myxilla incrustans (Esper, 1805)	4	ROM	98, 160
Stelodoryx alaskensis Lambe, 1894	1		8
Family Plocamiidae			
Plocamia sp.	1	ROM	98
Plocamia karykina de Laubenfels, 1927	1		8
Plocamissa igzo (de Laubenfels, 1932)	1	RBCM	
Wigginsia cf. *wigginsi* de Laubenfels	1		25
Family Tedaniidae			
Tedania gurjanovae Koltun, 1958	1		8
Order Haplosclerida			
Family Adociidae			
Adocia sp.	2		160
Adocia gellindra de Laubenfels, 1932	1		8
Family Haliclonidae			
Haliclona sp.	2		8, 268
Haliclona ecbasis de Laubenfels, 1930	1	RBCM	
Haliclona permollis Bowerbank, 1866	12	CMN, RBCM	62, 160, 161, 276
Haliclona cf. *permollis* (Bowerbank, 1866)	3		8, 10, 12
Orina sp.	3	RBCM	298
Reniera sp.	3		12, 22, 160
Reniera mollis Lambe, 1893	4	RBCM	8, 275
Order Petrosiida			
Family Petrosiidae			
Xestospongia sp.	1		12
Order Dendroceratida			
Family Aplysillidae			
Aplysilla sp.	4		10, 16, 237
Aplysilla glacialis (Merejkowsky, 1878)	5		160
Aplysilla cf. *glacialis* (Merejkowsky, 1878)	3		10, 11, 12
Chelonaplysilla polyraphis de Laubenfels, 1930	1		12
Family Halisarcidae			
Halisarca sp.	5		8, 12, 160

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Order Verongiida			
Family Verongiidae			
Hexadella sp.	1		8
Phylum Cnidaria (Jelly fishes, Sea anemones, Corals)			
Class Hydrozoa			
Order Hydroida			
Suborder Athecata			
Family Bougainvilliidae			
Bougainvillia sp.	4	CMN	92, 258
Bougainvillia multitentaculata Foerster, 1923	3	CMN	4, 92
Bythotiara depressa Naumov, 1960	4		155
Bythotiara huntsmani (Fraser, 1911)	1	RBCM	94
Garveia sp.	6		160, 237
Garveia annulata Nutting, 1901	10	RBCM	228, 237
Garveia gracilis Clark, 1876	3		228
Garveia groenlandica Levinson, 1893	2	RBCM	228
Garveia nutans Wright, 1859	3	CMN, RBCM	92
Perigonimus repens (Wright, 1858)	2		228
Perigonimus serpens Allman, 1863	3		227
Family Calycopsidae			
Calycopsis nematophora Bigelow, 1913	6	CMN, RBCM	94, 155
Heterotiara anonyma Maas, 1905	1	USNM	71
Family Clavidae			
?Hataia parva Hirai & Yamada, 1965	1		297
Tubiclava cornucopiae Norman, 1864	2	RBCM	228
Turritopsis nutricula McCrady, 1857	1		227
Family Corynidae			
Coryne sp.	1		23
Sarsia sp.	9	ROM	4, 91, 98, 155, 257
Sarsia cliffordi Brinckmann-Voss, 1988	2	CMN, RBCM	93
Sarsia tubulosa (Sars, 1835)	9		4, 5, 258
Syncoryne mirabilis (Agassiz, 1862)	2	CMN	228
Family Eudendriidae			
Eudendrium rameum (Pallas, 1766)	2		228
Eudendrium tenellum Allman, 1877	2	RBCM	228
Eudendrium vaginatum Allman, 1863	2	RBCM	228
Family Halimedusidae			
Halimedusa typus Bigelow, 1916	2		4
Family Hydractiniidae			
Hydractinia sp.	3	RBCM	
Hydractinia aggregata Fraser, 1911	4	RBCM	18, 228
Family Pandeidae			
Leuckartiara sp.	3		91

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Pandea rubra Bigelow, 1913	2	MCZ, USNM	5, 71
Stomotoca atra Agassiz, 1862	7		4, 5, 91, 155, 258
Family Polyorchidae			
Polyorchis penicillatus (Eschscholtz, 1829)	4	CMN	4, 5
Family Rathkeidae			
Rathkea sp.	1		257
Rathkea octopunctata (Sars, 1835)	10		4, 155, 258
Family Tubulariidae			
Tubulariidae	1	RBCM	
Euphysa japonica (Maas, 1909)	15		4, 155
Hybocodon sp.	2		142
Plotocnide borealis Wagner, 1885	3		258
Tubularia sp.	4		23, 160, 237
Tubularia aurea Fraser, 1936	3	RBCM	3, 227, 228
**Tubularia crocea* (Agassiz, 1862)	2		228
Tubularia marina Torrey, 1902	2		23, 297
Family Velellidae			
Velella velella Linnaeus, 1758	28		97
Family incertae sedis			
Paulinum lineatum Brinckman-Voss & Arai, 1998	1	RBCM	94
Suborder Thecata			
Family Aequoreidae			
Aequorea sp.	3		142
Aequorea victoria (Murbach & Shearer, 1902)	11		8, 9, 10, 258, 275
Family Aglaopheniidae			
Aglaophenia sp.	14	CAS	22, 160, 237
Aglaophenia latirostris Nutting, 1900	3	CMN	92, 228, 271
Aglaophenia struthionides (Murray, 1860)	16	CMN, RBCM	9, 12, 92, 225, 228, 276
Cladocarpus vancouverensis Fraser, 1914	2	RBCM	3, 228
Family Campanulariidae			
Campanulariidae	3	ROM	98
Campanularia sp.	3	CMN	92
Campanularia denticulata Clark, 1876	1	RBCM	
Campanularia gelitinosa (Pallas, 1766)	3		228
Campanularia gigantea Hincks, 1866	3	CMN, RBCM	92, 227
Campanularia groenlandica Levinsen, 1893	5		225, 228
Campanularia integra (MacGillivray, 1842)	4		228
Campanularia speciosa Clark, 1876	6	CMN	92, 225, 228
Campanularia verticillata (Linnaeus, 1758)	4		225, 228
Campanularia volubilis (Linnaeus, 1758)	5	CMN	92, 228
Clytia cylindrica Agassiz, 1862	2		228
Clytia edwardsi (Nutting, 1901)	7		228
Clytia johnstoni (Alder, 1856)	1		228
Clytia lomae (Torrey, 1909)	1		4
Eucopella caliculata (Hincks, 1853)	3		225, 228
Eucopella everta (Clark, 1876)	4		228
Gonothyraea clarcki (Marktanner-Turneretscher, 1895)	7		228
Gonothyraea gracilis (Sars, 1851)	3		228

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Gonothyraea inornata Nutting, 1901	5		228
Obelia sp.	11	ROM	4, 9, 10, 18, 19, 65, 98, 258
Obelia borealis Nutting, 1901	5		152, 225, 228
Obelia dichotoma (Linnaeus, 1758)	6	RBCM	66, 228
Obelia dubia Nutting, 1901	3		152, 228
Obelia geniculata (Linnaeus, 1758)	1		228
Obelia longissima (Pallas, 1766)	1		228
Phialidium sp.	9		142, 257
Phialidium gregarium (Agassiz, 1862)	17	CAS	4, 91, 155, 258
Phialidium hemisphaericum (Linnaeus, 1767)	3		225, 228
Phialidium kincaidi (Nutting, 1899)	2		228
Phialidium minutum (Nutting, 1901)	1		227
Family Campanulinidae			
Calycella sp.	1	CMN	92
Calycella syringa (Linnaeus, 1767)	8	RBCM	228
Cuspidella grandis Hincks, 1868	5	RBCM	225, 228
?Cuspidella humilis (Alder, 1862)	1		228
Family:Eirenidae			
Eutonina sp.	11		91, 155
Eutonina indicans (Romanes, 1876)	9		5, 91, 258
Family Haleciidae			
Halecium sp.	3	CMN, ROM	92, 98
Halecium annulatum Terrey, 1902	4		228
Halecium articulosum Clark, 1876	1		228
Halecium corrugatum Nutting, 1899	6		228
Halecium densum Calkins, 1899	6	RBCM	225, 228
Halecium flexile Allman, 1888	1	CMN	92
Halecium labrosum Alder, 1859	2		228
Halecium parvulum Bale, 1888	2		225, 228
Halecium pygmaeum Fraser, 1911	1		228
Halecium tenellum Hincks, 1861	8		225, 228
Halecium washingtoni Nutting, 1899	3	RBCM	228
Halecium wilsoni Calkins, 1899	5	CMN	92, 228
Ophiodissa sp.	1	RBCM	
Ophiodissa corrugata (Fraser, 1936)	1	RBCM	3, 228
Ophiodissa gracilis (Fraser, 1914)	2	RBCM	3, 225, 228
Family Lafoeidae			
Filellum serpens (Hassall, 1848)	4	RBCM	228
Grammaria immersa Nutting, 1901	1		228
Lafoea sp.	4	CMN, RBCM	92
Lafoea dumosa (Fleming, 1828)	11	CMN, ROM	92, 98, 225, 228
Family Lovenellidae			
Oplorhiza gracilis (Stechow, 1921)	2		228
Family Melicertidae			
Melicertum octocostatum (Sars, 1835)	3		4, 91
Family Mitrocomidae			
?Cosmetirella davisi (Browne, 1902)	1		91
Mitrocoma sp.	2		91
Mitrocoma cellularia (Agassiz, 1865)	10		5, 91, 155

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Mitrocomella polydiademata (Romanes, 1876)	5		258
Family Phialellidae			
Phialella sp.	2		257
Family Plumulariidae			
Plumulariidae	1		23
Plumularia sp.	15	CMN, RBCM, ROM	9, 14, 92, 98, 160
Plumularia lagenifera Allman, 1885	11	RBCM	225, 228
Plumularia setacea (Ellis, 1755)	2	CMN	92, 228
Tetranema furcata Fraser, 1931	1	RBCM	3
Family Sertulariidae			
Sertulariidae	1		271
Abietinaria sp.	16	CMN, RBCM, ROM	18, 92, 98, 160, 275
Abietinaria abietina (Linnaeus, 1758)	7	RBCM	225, 228
Abietinaria amphora Nutting, 1904	4		228
Abietinaria anguina (Trask, 1857)	6		225, 228
Abietinaria costata (Nutting, 1901)	1		228
Abietinaria filicula (Ellis & Solander, 1786)	2		228
Abietinaria gigantea (Clark, 1876)	2		228
Abietinaria greenei (Murray, 1860)	6		228
Abietinaria rigida Fraser, 1911	5	CMN, RBCM	3, 92, 228
Abietinaria traski (Torrey, 1902)	1	USNM	225
Abietinaria turgida (Clark, 1876)	8	RBCM	228, 271
Abietinaria urceolus Naumov, 1960	1	RBCM	
Abietinaria variabilis (Clark, 1876)	13	CMN, RBCM	92, 225, 228
Amphisbetia furcata (Trask, 1857)	1		228
Diphasia pulchra Nutting, 1904	1	CMN	92
Hydrallmania sp.	3	CMN	92
Hydrallmania distans Nutting, 1899	8	RBCM, ROM	98, 225, 228
Selaginopsis sp.	2	CMN	92
Selaginopsis alternitheca (Levinsen, 1893)	1	CMN	92
Selaginopsis cylindrica (Clark, 1876)	15	CMN, RBCM	92, 225, 228
Selaginopsis mirabilis (Verrill, 1872)	3	RBCM	225, 228
Selaginopsis ornata Nutting, 1904	4	RBCM	18
Selaginopsis trilateralis Fraser, 1936	6	CMN, RBCM	3, 92, 227, 228
Sertularella sp.	19	CMN, RBCM, ROM	92, 98, 160
Sertularella albida Kirchenpauer, 1884	2	RBCM	228
Sertularella conica Allman, 1877 of Fraser, 1937	3		228
Sertularella polyzonias Torrey, 1904	1		228
Sertularella rugosa (Linnaeus, 1758)	4	ROM	98, 228
Sertularella tanneri Nutting, 1904	1		228
Sertularella tenella (Alder, 1857)	6		225, 228
Sertularia sp.	11	CMN, RBCM	65, 92, 160
Sertularia cupressina (Linnaeus, 1758)	6	RBCM	225, 228
Sertularia cupressoides Clark, 1876	9		225, 228
Sertularia fabricii (Levinsen, 1892)	3	RBCM	228
Symplectoscyphus sp.	1	RBCM	
Symplectoscyphus pinnatus (Clark, 1876)	1		228
Symplectoscyphus tricuspidata (Alder, 1856)	8	CMN, RBCM	92, 228
Symplectoscyphus turgidus (Trask, 1857)	10	CMN, RBCM, USNM	92, 228

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Thuiaria sp.	11	CMN, RBCM	92, 298
Thuiaria alba Fraser, 1911	1	RBCM	3, 228
Thuiaria distans Fraser, 1914	1	RBCM	3, 228
Thuiaria similis (Clark, 1876)	7	CMN, RBCM	92, 225, 228
Thuiaria tenera Sars, 1874	1	RBCM	
Thuiaria thuiaroides (Clark, 1876)	7	CMN	92, 225, 228
Suborder Limnomedusae			
Family Olindiasidae			
Eperetmus typus Bigelow, 1915	4		4, 5, 91
Gonionemus vertens Agassiz, 1862	10	CMN, RBCM	4, 91, 271
Monobrachium parasitum Mereschkowsky, 1877	1		228
Family Proboscidactylidae			
Proboscidactyla sp.	4		142, 257
Proboscidactyla flavicirrata Brandt, 1835	14		4, 5, 155
Order Stylasterida			
Family Stylasteridae			
Allopora sp.	7	RBCM	8, 9, 10
Allopora venusta Verrill, 1870	2	CMN, YPM	305
Errinopora pourtalesi (Dall, 1884)	2		8
Stylantheca sp.	4		10, 16
Stylantheca petrograpta (Fisher, 1938)	27		160, 161, 275, 276
Stylantheca porphyra Fisher, 1931	1		160
Order Trachylina			
Suborder Trachymedusae			
Family Halicreatidae			
Botrynema brucei Browne, 1908	1	USNM	152
Family Rhopalonematidae			
Aglantha sp.	2		91, 142
Aglantha digitalis (Müller, 1776)	36		4, 71, 155
Colobonema sp.	1		155
Colobonema rufobrunnae (Kramp, 1913)	4		71, 155
Pantachogon haeckeli Mass, 1893	3		5, 71, 155
Suborder Narcomedusae			
Family Aeginidae			
Aegina citrea Eschscholtz, 1829	2	CMN	155
Family Cuninidae			
Solmissus incisus (Fewkes, 1886)	2		71
Solmissus marshalli Agassiz & Mayer, 1902	14		155
Order Siphonophora			
Suborder Physonectae			
Family Agalmidae			
Agalma elegans Sars, 1846	3		56
Family Apolemiidae			
Apolemia uvaria Lesueur, 1811	1		56

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Forskaliidae			
Forskalia sp.	1		56
Forskalia edwardsi Koelliker, 1853	1		8
Suborder Calycophorae			
Family Diphyidae			
Chuniphyes multidentata Lens & Riemsdijk, 1908	1		71
Dimophyes sp.	1		257
Dimophyes arctica (Chun, 1897)	1		71
Lensia baryi Totton, 1965	2		142, 257
Muggiaea sp.	7		258
Muggiaea atlantica Cunningham, 1892	1		142
Muggiaea kochi (Will, 1844)	2	MCZ	71
Class Scyphozoa			
Order Semaeostomeae			
Family Cyaneidae			
Cyanea capillata Stiasny, 1921	15		4, 8, 9, 10, 193, 275, 298
Family Pelagiidae			
Chrysaora fuscescens Brandt, 1835	1	RBCM	
Family Ulmaridae			
Aurelia sp.	2		8, 9
Aurelia labiata Chamisso & Eysenhardt, 1821	1		4
Order Coronatae			
Family Atollidae			
Atolla sp.	9	RBCM	
Atolla vanhoeffeni Russel, 1957	3		155
Atolla wyvillei Haeckel, 1880	3		71
Family Periphyllidae			
Periphylla sp.	8	RBCM	
Periphylla periphylla (Peron & Lesueur, 1809)	9	CMN	71, 155
Order Stauromedusae			
Haliclystus sp.	2	CMN	271
Class Anthozoa			
Subclass Alcyonaria			
Order Alcyonacea			
Suborder Stolonifera			
Family Clavulariidae			
Clavularia sp.	1		9
Suborder Alcyoniina			
Family Alcyoniidae			
Anthomastus sp.	1	RBCM	
Anthomastus cf. *glandiflora* Verrill, 1878	1		17
Anthomastus ritteri Nutting, 1909	1	USNM	
Family Nephtheidae			
Gersemia sp.	1	USNM	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Gersemia rubiformis (Ehrenberg, 1834)	23	RBCM	8, 9, 10, 12, 13, 16, 160, 161, 237,276
Suborder Holaxonia			
Family Isididae			
Lepidisis sp.	1	USNM	
Family Plexauridae			
Swiftia pacifica (Nutting, 1909)	1	USNM	
Family Primnoidae			
Primnoa sp.	2	CMN, RBCM	
Primnoa willeyi Hickson, 1915	5	RBCM, ROM	23
Suborder Scleraxonia			
Family Paragorgiidae			
Paragorgia sp.	2	RBCM	
Paragorgia pacifica Verrill, 1922	5	RBCM	23
Order Pennatulacea			
Suborder Subselliflorae			
Family Kophobelemnidae			
Kophobelemnon hispidum Nutting, 1912	1		15
Suborder Sessiliflorae			
Family Pennatulidae			
Pennatulidae	2		98
Ptilosarcus sp.	50		259
Ptilosarcus gurneyi Gray, 1860	6	RBCM, ROM	1, 10, 98, 275, 276
Family Virgulariidae			
Balticina californica Moroff, 1902	2		7
Balticina septentrionalis (Gray, 1872)	8		18, 19, 23
Stylatula sp.	5	RBCM	24, 259
Stylatula elongata Verrill, 1864	1	RBCM	
Virgularia sp.	1	RBCM	
Virgularia cystiferum (Nutting, 1909)	1		7
Subclass Ceriantipatharia			
Order Ceriantharia			
Suborder Spirularina			
Family Cerianthidae			
Pachycerianthus fimbriatus Mcmurrich, 1910	10	RBCM	1, 9, 10, 275, 276
Subclass Zoantharia			
Order Scleractinia			
Suborder Caryophylliina			
Family Caryophylliidae			
Caryophyllia alaskensis (Vaughan, 1941)	8	CMN	8, 275, 276
Caryophyllia arnoldi Vaughan, 1900	1	RBCM	
Paracyathus sp.	7	CMN, RBCM	
Paracyathus stearnsi Verrill, 1869	15	RBCM, USNM, YPM	8, 9, 13, 16, 20, 22, 209, 305

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Flabellidae			
Javania cailleti (Duchass & Michelotti, 1864)	2	CMN	
Suborder Dendrophylliina			
Family Dendrophylliidae			
Balanophyllia elegans Verrill, 1864	75	RBCM, YPM	1, 8, 9, 10, 11, 12, 13, 16, 20, 22, 160, 161, 193, 237, 275, 276, 297, 298, 305
Order Actiniaria			
Suborder Nynantheae			
Family Actiniidae			
Actiniidae	3	RBCM	
Anthopleura sp.	4		268, 271
Anthopleura artemisia (Pickering & Dana, 1848)	4	RBCM	160, 276
Anthopleura elegantissima (Brandt, 1835)	58	RBCM	8, 9, 10, 160, 238, 268, 275, 276
Anthopleura xanthogrammica (Brandt, 1835)	91	RBCM	8, 9, 10, 22, 160, 161, 268, 275, 276, 297, 298
Aulactinia incubans Dunn, Chia & Levine, 1980	1	CAS	
Cribrinopsis sp.	1		10
Cribrinopsis fernaldi Siebert & Spalding, 1976	10	RBCM	22, 23
Epiactis sp.	23	CAS	11, 160
Epiactis fernaldi Fautin & Chia, 1986	2	CAS	298
Epiactis lisbethae Fautin & Chia, 1986	1	RBCM	
Epiactis prolifera Verrill, 1869	32	CAS	9, 193, 268, 276
Epiactis ritteri Torrey, 1902	2	CAS	
Liponema sp.	2	RBCM	
Liponema brevicorne (McMurrich, 1893)	1	CAS	
Urticina sp.	8	RBCM	9, 11, 268, 271
Urticina columbiana (Verrilll, 1922)	1	RBCM	
Urticina coriacea (Cuvier, 1798)	20	RBCM	16, 160, 161, 275, 276
Urticina crassicornis (Müller, 1776)	25	CAS	9, 10, 13, 22, 160, 238, 268, 275, 276
Urticina lofotensis (Danielssen, 1890)	73	RBCM	9, 13, 16, 160, 275, 276, 298
Urticina piscovora (Sebens & Laasko, 1977)	26		12, 13, 14, 20, 275, 276, 298
Family Actinoscyphiidae			
Actinoscyphia sp.	1	RBCM	
Family Actinostolidae			
Actinostolidae	2	CAS, RBCM	
Actinostola sp.	1	RBCM	
Paractinostola faeculenta McMurrich, 1893	4	CAS, RBCM	
Parasicyonis sarsii Carlgren, 1921	2	CAS	
Stomphia sp.	10	CAS, RBCM	8, 9, 22, 298
Stomphia coccinea (Müller, 1776)	1	RBCM	
Family Condylanthidae			
Charisia saxicola Torrey, 1902	1		271
Family Edwardsiidae			
?*Nematostella vectensis* Stephenson, 1935	1		12

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Halcampidae			
Halcampa decemtentaculata Hand, 1954	1	ROM	98
Family Haliplanellidae			
Haliplanella sp.	1	CMN	
Family Hormathiidae			
Actinauge sp.	3	RBCM	
Actinauge verrillii (McMurrich, 1893)	6	CAS, CMN	
Allantactis parasitica Danielssen, 1890	1		18
Paraphelliactis pabista Dunn, 1982	9	CAS, CMN, RBCM, USNM	143, 154
Family Metridiidae			
Metridium sp.	18	RBCM	22, 237, 259, 268
Metridium farcimen (Brandt, 1835)	10	RBCM	22, 23, 160, 161, 237
Metridium senile (Linnaeus, 1767)	84	CAS, CMN, RBCM	10, 12, 13, 16, 20, 22, 160, 161, 268, 271, 275, 276, 297, 298
Suborder Prothantheae			
Family Gonactiniidae			
Gonactiniidae	1	RBCM	
Order Corallimorpharia			
Family Corallimorphidae			
Corallimorphus sp.	2	RBCM	17
Corynactis californica Carlgren, 1936	2	CMN	276
Order Zoanthidea			
Family Epizoanthidae			
Epizoanthus scotinus Wood, 1958	11		8, 9, 10, 11, 13, 22, 268, 297
Class Myxozoa			
Order Bivalvulida			
Family Ceratomyxidae			
Ceratomyxa drepanopsettae Averintzev, 1908	1		73
Ceratomyxa platichthys (Fujita, 1923)	1		73
Leptotheca sp.	1		73
Suborder Variisporina			
Family Myxidiidae			
Myxidium incurvatum Thélohan, 1892	1		73
Zschokella sp.	1		73
Order Multivalvulida			
Family Multivalvulida			
Kudoa thyrsites (Gilchrist, 1924)	1		73
Family Trilosporidae			
Unicapsula sp.	1		73

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Phylum Ctenophora (Comb Jellies)			
Class Tentaculata			
Order Cydippida			
Family Pleurobrachiidae			
Hormiphora sp.	1		9
Hormiphora cucumis (Mertens, 1833)	2		8, 10
Pleurobrachia sp.	9		99, 257, 258
Pleurobrachia bachei Agassiz, 1860	9	RBCM	4, 8, 142
Order Lobata			
Family Bolinopsidae			
Bolinopsis infundibulum (Müller, 1776)	1		10
Class Nuda			
Nuda sp.	2	RBCM	
Order Beroida			
Family Beroidae			
Beroe sp.	11	RBCM	155
Beroe cucumis Fabricius, 1789	1		8
Phylum Platyhelminthes (Flatworms)			
Class Cestoda			
Abothrium gadi van Beneden, 1871	3		6, 218, 260
Bothriocephalus sp.	1		280
Bothriocephalus scorpii (Müller, 1776)	2		73, 279
Nybelinia surmenicola Okada in Dollfus, 1929	6		6, 73, 260, 277, 279, 280
Phyllobothrium sp.	3		277, 279, 280
Phyllobothrium delphini (Bosc, 1802)	1		218
Scolex pleuronectis Müller, 1788	1		73
Family Tetrabothriidae			
Tetrabothrius sp.	1		218
Subclass Eucestoda			
Order Pseudophyllidea			
Family Amphicotylidae			
Diplogonoporus sp.	1		218
Diplogonoporus balaenopterae Lönnberg, 1892	1		218
Diplogonoporus fasciatus (Krabbe, 1865)	1		218
Diplogonoporus tetrapterus (von Siebold, 1848)	1		218
Family Diphyllobothriidae			
Diphyllobothrium sp.	1		218
Diphyllobothrium alascense Rausch & Williamson, 1958	1		218
Diphyllobothrium lanceolatum (Krabbe, 1865)	1		218
Diphyllobothrium osmeri (von Listow, 1878)	1		218
Diphyllobothrium pacificum (Nybelin, 1931)	1		218
Pyramicocephalus phocarum (Fabricius, 1780)	1		218

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Class Monogenea			
Order Heteroptera			
Infraorder Gerromorpha			
Family Veliidae			
Trochopus sp.	1		280
Trochopus marginata (Folda, 1928)	1		279
Order Monopisthocotylea			
Family Capsalidae			
Benedenia derzhavini (Layman, 1930)	1		280
Entobdella hippoglossi (Müller, 1776)	1		73
Entobdella pugetensis Robinson, 1961	1		73
Order Polyopisthocotylea			
Family Microcotylidae			
Microcotyle sp.	1		280
Microcotyle sebastis Goto, 1894	3		277, 279, 280
Class Trematoda			
Subclass Digenea			
Order Azygiida			
Suborder Azygiata			
Family Azygiidae			
Otodistomum sp.	1		73
Suborder Hemiurata			
Family Hemiuridae			
Hemiuridae	1		280
Brachyphallus crenatus (Rudolphi, 1802)	1		73
Derogenes varicus (Müller, 1784)	4		73, 277, 279, 280
Dissosaccus laevis unk	1		73
Genolinea laticauda Manter, 1925	1		73
Gonocerca phycidis Manter, 1925	1		73
Hemiuris levinseni unk	1		73
Lecithaster gibbosus (Rudolphi, 1802)	2		73, 280
Lecithophyllum botryophorum (Olsson, 1868)	3		73, 279, 280
Parahemiuris merus unk	1		73
Tubulovesicula lindbergi (Layman, 1930)	4		73, 277, 279, 280
Family Lampritrematidae			
Lampritrema sp.	1		73
Family Syncoeliidae			
Copiatestes filiferus (Leuckart in Sars, 1885)	1		280
Order Echinostomida			
Suborder Echinostomata			
Family Campululidae			
Hadwenius nipponicus Yamaguti, 1951	1		218
Family Echinostomatidae			
Stephanoprora denticulata (Rudolphi, 1802)	1		218

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Fasciolidae			
Fascioloides magna (Bassi, 1875)	1	RBCM	
Suborder Paramphistomata			
Family Notocotylidae			
Ogmogaster antarcticus Johnston, 1931	1		218
Ogmogaster pentalineatus Rausch & Fay, 1966	1		218
Ogmogaster plicatus (Creplin, 1829)	1		218
Ogmogaster trilineatus Rausch & Rice, 1970	1		218
Order Opisthorchiida			
Suborder Acanthocolpiata			
Family Acanthocolpidae			
Stephanostomum dentatum (Linton, 1900)	1		280
Family Campulidae			
Campula oblonga Cobbold, 1858	1		218
Lecithodesmus sp.	1		218
Lecithodesmus goliath (van Beneden, 1858)	1		218
Lecithodesmus spinosus Margolis & Pike, 1955	1		218
Orthosplanchnus fraterculus Odhner, 1905	1		218
Zalophotrema hepaticum Stunkard & Alvey, 1929	1		218
Suborder Opisthorchiata			
Family Heterophyidae			
Cryptocotyle jejuna (Nicoll, 1907)	1		218
Phocitrema fusiforme Goto & Ozaki, 1930	1		218
Pricetrema zolophi (Price, 1932)	1		218
Stictodora ubelakeri Dailey, 1969	1		218
Family Nasitrematidae			
Nasitrema globicephalae Neiland, Rice & Holden, 1970	1		218
Order Plagiorchiida			
Suborder Allocreadiata			
Family Lepocreadiidae			
Lepocreadium sp.	1		73
Neolepidapedon sebastici (Yamaguti, 1938)	1		280
Opechona alaskensis Ward & Fillingham, 1934	3		277, 279, 280
Opechona occidentalis Montgomery, 1957	1		280
Suborder Opecoelata			
Family Opecoelidae			
Neohelicometra sebastis Sekarak & Arai, 1974	3		277, 279, 280
Podocotyle sp.	4		73, 277, 279, 280
Podocotyle gibbonsia Johnson, 1949	1		73
Pseudopecoelus nassamani unk	1		73
Suborder Plagiorchiata			
Family Microphallidae			
Microphallus pirum (Afanas'ev, 1941)	1		218
Suborder Zoogonata			
Family Steganodermatidae			
Steganoderma formosum Stafford, 1904	1		73

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Zoogonidae			
Zoogonus dextrocirrus unk	1		73
Order Strigeata			
Suborder Brachylaimata			
Family Bucephalidae			
Prosorhynchoides basargini (Layman, 1930)	2		73, 260
Prosorhynchus sp.	3		6, 73, 260
Prosorhynchus crucibulum (Rudolphi, 1819)	3		277, 279, 280
Rhipidocotyle sp.	2		6, 260
Family Fellodistomatidae			
Fellodistomum sebastodis Yamaguti & Matumura, 1942	3		277, 279, 280
Stenakron vetustum Stafford, 1904	1		73
Order Strigeatida			
Family Sanguinicolidae			
Aporocotyle simplex Odhner, 1900	1		73
Aporocotyle theragrae Ichihara, 1970	1		6
Psettarium sebastodorum Holmes, 1971	3		277, 279, 280
Class Turbellaria			
Subclass Archoophora			
Order Polycladida			
Family Leptoplanidae			
Notoplana sp.	1		65
Family Stylochidae			
Kaburakia excelsa Bock, 1925	2	RBCM	298
Suborder Cotylea			
Family Euryleptidae			
Acerotisa arctica Hyman, 1953	1	CMN	
Family Pseudoceritidae			
Pseudoceros canadensis Hyman, 1953	3	RBCM	271, 297
Suborder Leptoplanoidea			
Family Notoplanidae			
Notocomplana litoricola (Heath & McGregor, 1912)	1		271
Phylum Nemertea (Ribbon Worms)			
Class Anopla			
Order Paleonemertea			
Family Carinomidae			
Carinoma sp.	2	RBCM	
Family Tubulanidae			
Tubulanus sp.	1		18
Tubulanus pellucidus (Coe, 1895)	1		297
Tubulanus polymorphus Renier, 1804	4		9, 275, 297
Tubulanus sexlineatus (Griffin, 1898)	1		297

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Order Heteronemertea			
Family Lineidae			
Cerebratulus sp.	5	RBCM, ROM	13, 98
Cerebratulus albifrons Coe, 1901	3		160, 297
Cerebratulus californiensis Coe, 1905	1		23
Cerebratulus herculeus Coe, 1901	3		9, 18
Cerebratulus marginatus Renier, 1804	2		160
Lineus sp.	1	RBCM	
Lineus vegetus Coe, 1931	1		297
Micrura sp.	4	RBCM	
Micrura alaskensis Coe, 1901	4	RBCM	297, 298
Micrura verrilli Coe, 1901	1		268
Class Enopla			
Order Hoplonemertea			
Suborder Monostilifera			
Family Amphiporidae			
Amphiporidae	1	RBCM	
Amphiporus sp.	9	RBCM	65, 160, 297, 298
Amphiporus bimaculatus Coe, 1901	6	RBCM	8, 10, 297, 298
Amphiporus formidabilis Griffin, 1898	3		160
Amphiporus imparispinosis Griffin, 1898	3		160, 297, 298
Family Carcinonemertidae			
Carcinonemertes errans Wickham, 1978	1		307
Family Emplectonematidae			
Emplectonema gracile (Johnston, 1837)	2		10, 268
Paranemertes peregrina Coe, 1901	3	RBCM	160, 297
Family Tetrastemmatidae			
Tetrastemma sp.	1		297
Suborder Polystylifera			
Family Nectonemertidae			
Pelagonemertes brinckmanni Coe, 1926	2	USNM	
Phylum Nematoda (Round Worms)			
Class Adenophorea			
Subclass Chromadoria			
Order Araeolaimida			
Family Tripyloididae			
Tripyloides gracilis (Ditlevson, 1918)	1		66
Subclass Enoplia			
Order Enoplida			
Family Enoplidae			
Enoplus sp.	1		66

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Class Aphasmida			
Order Trichurida			
Superfamily Trichinelloidea			
Family Trichinellidae			
Trichinella spiralis (Owen, 1835)	1		218
Class Nemata			
Order Metastrongyloidea			
Pharurus convolutus (Kühn, 1829)	1		218
Order Nemata			
Capillaria sp.	1		280
Capillaria margolisi unk	1		73
Paracapillaria parophrysi (Moravec, Margolis & MacDonald, 1981)	1		73
Pseudoterranova decipiens (Krabbe, 1878)	3		6, 73, 260
Family Pseudaliidae			
Halocercus invaginatus (Queckitt, 1841)	1		218
Halocercus kirbyi Dougherty, 1944	1		218
Stenurus minor (Kühn, 1829)	1		218
Class Secernentea			
Order Ascaridida			
Family Anisakidae			
Anisakis sp.	1		218
Anisakis physeteris Baylis, 1923	1		218
Anisakis similis (Baird, 1853)	1		218
Anisakis simplex (Rudolphi, 1809)	3		6, 73, 260
Anisakis typica (Diesing, 1860)	1		218
Contracaecum sp.	4		6, 73, 218, 260
Contracaecum osculatum (Rudolphi, 1802)	1		218
Dujardinia sp.	1		218
Hysterothylacium sp.	3		277, 279, 280
Hysterothylacium aduncum (Rudolphi, 1802)	4		73, 260, 279, 280
Terranova decipiens (Krabbe, 1878)	1		218
Family Cucullanidae			
Cucullanus sp.	1		280
Cucullanus heterochrous Rudolphi, 1802	1		73
Family Toxocaridae			
Porrocaecum sp.	1		218
Order Spirurida			
Family Spiruridae			
Ascarophis filiformis Poljansky, 1952	1		73
Ascarophis sebastodis Olsen, 1952	1		280
Family Tetrameridae			
Crassicauda sp.	1		218
Crassicauda pacifica Margolis & Pike, 1955	1		218
Placentonema sp.	1		218
Placentonema gigantissima Gubanov, 1951	1		218

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Superfamily Filarioidea			
Family Setariidae			
Dipetalonema odendhali Perry, 1967	1		218
Dipetalonema spirocauda (Leidy, 1858)	1		218
Order Strongylida			
Superfamily Ancylostomoidea			
Family Ancylostomatidae			
Uncinaria sp.	1		218
Uncinaria hamiltoni Bayliss, 1933	1		218
Uncinaria lucasi Stiles, 1901	1		218
Superfamily Metastrongyloidea			
Family Filaroididae			
Parafilaroides sp.	1		218
Parafilaroides decorus Dougherty & Herman, 1947	1		218
Parafilaroides nanus Dougherty & Herman, 1947	1		218
Parafilaroides prolificus Dougherty & Herman, 1947	1		218
Phylum Gastrotricha			
Order Chaetonotoida			
Family Chaetonotidae			
Musellifer sp.	1		65
Order Macrodasyidae			
Family Turbanellidae			
?Turbanellidae	1		13
Phylum Kinorhyncha (Snout Movers)			
Order Cyclorhagida			
Family Echinoderidae			
?*Echinoderes* sp.	1		65
Phylum Priapulida			
Order Priapulomorpha			
Family Priapulidae			
Priapulus caudatus Lamarck, 1816	2	RBCM	298

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Phylum Acanthocephala			
Class Palaeacanthocephala			
Order Polymorphida			
Family Polymorphidae			
Bolbosoma sp.	2		73, 218
Bolbosoma balaenae (Gmelin, 1790)	1		218
Bolbosoma turbinella (Diesing, 1851)	1		218
Corynosoma sp.	2		73, 280
Corynosoma alaskensis Golvan, 1959	1		218
Corynosoma enhydri Morozov, 1940	2		73, 218
Corynosoma falcatum Van Cleave, 1953	1		218
Corynosoma obtuscens Lincicome, 1943	1		218
Corynosoma semerme (Forssell, 1904)	1		218
Corynosoma similis Neiland, 1962	1		218
Corynosoma strumosum (Rudolphi, 1802)	2		73, 218
Corynosoma villosum Van Cleave, 1953	3		73, 218, 279
Corynosoma wegeneri Heinze, 1934	1		218
Class Archiacanthocephala			
Order Moniliformida			
Family Moniliformidae			
Echinorhynchus gadi Zoega in Müller, 1776	2		73, 280
Phylum Annelida (Segmented Worms)			
Class Clitellata			
Subclass Hirudinea			
Order Rhynchobdellida			
Family Piscicolidae			
Piscicolidae	3	RBCM	
Beringbdella rectangulata (Levinsen, 1882)	1		217
Notostomobdella cyclostoma (Johansson, 1898)	1		243
Piscicola sp.	1		280
Subclass Oligochaeta			
Order Haplotaxida			
Suborder Tubificina			
Family Enchytraeidae			
Enchytraeidae	3	ROM	
Cognettia sp.	1	ROM	
Enchytraeus sp.	1	ROM	
Enchytraeus kincaidi Eisen, 1904	5	ROM	
Enchytraeus multiannulatus Altman, 1936	1	ROM	
Grania paucispina (Eisen, 1904)	5	ROM	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Marionina sp.	3	ROM	
Marionina appendiculata Nielsen & Christensen, 1959	2	ROM	
Marionina klaskisharum Coates, 1983	1		117
Marionina neroutsensis Coates, 1980	1	ROM	
Marionina nevisensis (Righi & Kanner, 1979)	1		117
Marionina sjaelandica Nielsen & Christensen, 1961	2	ROM	
Marionina southerni (Cernosvitov, 1937)	2	ROM	117
Marionina vancouverensis Coates, 1980	7	ROM	
Mesenchytraeus sp.	1	ROM	
Family Naididae			
Naididae	2	ROM	
Paranais litoralis (Müller, 1784)	1	ROM	
Family Tubificidae			
Aktedrilus oregonensis Strehlow, 1982	4	USNM	
Bacescuella labeosa Baker & Erseus, 1982	1		31
Bathydrilus litoreus Baker, 1983	3	USNM	
Limnodriloides sp.	1	ROM	
Limnodriloides monothecus Cook, 1974	2	ROM, USNM	
Limnodriloides victoriensis Brinkhurst & Baker, 1979	3	USNM	
Lumbricillus sp.	3	ROM	
Lumbricillus pagenstecheri (Ratzel, 1869)	4	ROM	
Lumbricillus qualicumensis Tynen 1969	6	ROM	
Lumbricillus tuba Stephenson, 1911	9	ROM	
Monopylephorus cuticulatus Baker & Brinkhurst, 1981	2	ROM, USNM	30
Monopylephorus rubroniveus Levinsen, 1884	1	ROM	
Nootkadrilus compressus Baker, 1982	2	ROM, USNM	
Nootkadrilus hamatus Baker, 1982	4	CMN, USNM	28
Phallodrilus tempestatis Baker, 1981	5	USNM	27
Rhizodrilus pacificus (Brinkhurst & Baker, 1979)	2	ROM, USNM	
Tubificoides sp.	1	ROM	
Class Polychaeta			
Subclass Scolecida			
Family Arenicolidae			
Arenicolidae	3	RBCM	298
Abarenicola sp.	5		268
Abarenicola claparedii oceanica Healy & Wells, 1959	1	CMN	
Abarenicola pacifica Healy & Wells, 1959	2	CMN	268
Arenicola sp.	1		9
Arenicola marina (Linnaeus, 1758)	1		298

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Capitellidae			
Capitellidae	4	ROM	98, 160
Barantolla americana Hartman, 1963	2	RBCM	298
Capitella sp.	2	RBCM, ROM	297
Capitella capitata (Fabricius, 1780)	6	ROM	98
Decamastus gracilis Hartman, 1963	36	ROM	98, 160
Mediomastus sp.	35	ROM	98
Mediomastus californiensis Hartman, 1944	1	ROM	98
Mediomastus capensis Day, 1961	5	ROM	98, 291
Notomastus sp.	4	ROM	98
Notomastus lineatus Claparède, 1870	24	ROM	98
Notomastus tenuis Moore, 1909	4	RBCM	297, 298
Family Cossuridae			
Cossura sp.	4	ROM	98, 160, 298
Cossura pygodactylata Jones, 1956	12	ROM	56, 98, 160
Cossura soyeri Laubier, 1964	2	ROM	98
Family Maldanidae			
Maldanidae	54	RBCM, ROM	98, 298
Chirimia similis (Moore, 1906)	18	CMN, RBCM	281
Clymenella rubrocincta (Johnson, 1901)	11	RBCM, ROM	11, 98, 298
Clymenella torquata (Leidy, 1855)	2	RBCM	298
Clymenura columbiana (Berkeley, 1929)	10	ROM	98
Euclymene zonalis (Verrill, 1874)	33	ROM	98
Euclymene cf. *zonalis* (Verrill, 1874)	6	ROM	98
Isocirrus longiceps (Moore, 1923)	2	ROM	98
Macroclymene sp.	1	ROM	98
Maldane sp.	1	ROM	98
Maldane glebifex Grube, 1860	7	ROM	65, 66, 98
Maldanella harai (Izuka, 1902)	2		49, 52
Micromaldane ornithochaeta Mesnil, 1897	3	ROM	98
Nicomache sp.	2	ROM	98
Nicomache lumbricalis (Fabricius, 1780)	11	ROM	98, 305
Nicomache personata Johnson, 1901	3	ROM	52, 65, 98
Notoproctus pacificus (Moore, 1906)	7	ROM	98
Petaloproctus tenuis borealis Arwidsson, 1907	3	ROM	98
Petaloproctus tenuis tenuis (Théel, 1879)	3	ROM	98
Praxillella sp.	1	ROM	98
Praxillella gracilis (Sars, 1861)	4	ROM	98
Praxillella praetermissa Mälmgren, 1866	1	ROM	98
Rhodine bitorquata Moore, 1923	12	ROM	98
Family Opheliidae			
Opheliidae	6	ROM	98
Ammotrypanella breviata (Ehlers, 1913)	3	RBCM, ROM	98, 178
Armandia sp.	2	CMN	
Armandia brevis Moore, 1906	18	RBCM, ROM	52, 65, 66, 98, 297, 298
Euzonus sp.	1		297
Ophelia sp.	5	RBCM, ROM	98, 297
Ophelia limacina (Rathke, 1843)	5	ROM, YPM	98
Ophelina sp.	5	CMN, RBCM, ROM	98
Ophelina acuminata Örsted, 1843	16	ROM	98

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Travisia sp.	4	RBCM, ROM	98, 297
Travisia brevis Moore, 1923	27	CMN, ROM	65, 98
Travisia gigas Hartman, 1938	1		57
Travisia pupa Moore, 1906	10	CMN, RBCM, ROM	18, 98
Family Orbiniidae			
Orbiniidae	1		160
Leitoscoloplos panamensis Monro, 1933	1	RBCM	
Leitoscoloplos pugettensis Pettibone, 1957	30	CMN, RBCM, ROM	98, 291, 298
Naineris sp.	1		297
Naineris dendritica Kinberg, 1867	6	RBCM	49, 52, 297, 298
Naineris uncinata Hartman, 1957	5	CMN, ROM	98
Orbinia sp.	1	ROM	98
Phylo felix Kinberg, 1866	8	ROM	98
Scoloplos acmeceps Chamberlin, 1919	17	ROM	54, 98
Scoloplos armiger (Müller, 1776)	1		98
Family Paraonidae			
Allia nolani (Webster & Benedict, 1887)	20		98, 160
Aricidea sp.	1		98
Aricidea cerruti Laubier, 1966	17	ROM	98
Aricidea cf. *cerruti* Laubier, 1966	5	ROM	98
Aricidea lopezi Berkeley & Berkeley, 1956	1		98
Aricidea cf. *lopezi* Berkeley & Berkeley, 1956	2	ROM	98
Aricidea minuta Southward, 1956	7	ROM	98, 291
Aricidea neosuecica (Hartman, 1965)	24	ROM	98
Aricidea quadrilobata Webster & Benedict, 1887	5	RBCM, ROM	98
Aricidea ramosa Annenkova, 1934	13	ROM	98
Aricidea cf. *suecica* Eliason, 1920	20	ROM	98
Levinsenia gracilis (Tauber, 1879)	23	ROM	98, 160
Paraonella sp.	2	RBCM	297
Paraonella platybranchia Hartman, 1961	2	RBCM	297
Family Questidae			
Questa caudicirra Hartman, 1966	2	RBCM	297
Family Scalibregmatidae			
Asclerocheilus beringianus Ushakov, 1955	3		98
Scalibregma inflatum Rathke, 1843	17	ROM	98
Subclass Palpata			
Order Aciculata			
Suborder Eunicida			
Family Amphinomidae			
Amphinomidae	2		23, 98
Family Dorvilleidae			
Dorvilleidae	2	ROM	98
Dorvillea moniloceras (Moore, 1909)	2	RBCM	298
Dorvillea pseudorubrovittata Berkeley, 1927	2	ROM	98
Protodorvillea gracilis (Hartman, 1938)	8	ROM	56, 98
Schistomeringos annulata (Moore, 1909)	1		98

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Eunicidae			
Eunice biannulata Moore,	4	USNM	50, 271
Eunice kobiensis McIntosh, 1885	6	CMN, USNM	49, 50
Eunice valens (Chamberlin, 1919)	2		65, 66
Family Euphrosinidae			
Euphrosine sp.	1		8
Euphrosine bicirrata Moore, 1905	2	RBCM, USNM	
Euphrosine hortensis Moore, 1905	2	RBCM	
Family Lumbrineridae			
Lumbrineridae	3	ROM	98
Lumbrineris sp.	32	RBCM, ROM	23, 65, 66, 98, 268, 296
Lumbrineris acuta Verrill, 1875	22	ROM	98
Lumbrineris bicirrata Treadwell, 1929	17	RBCM, ROM	98
Lumbrineris lagunae Fauchald, 1970	1	ROM	98
Lumbrineris latreilli Audouin & Milne-Edwards, 1834	6	RBCM, ROM	49, 50, 98, 298
Lumbrineris limicola Hartman, 1944	3	ROM	98
Lumbrineris luti Berkeley & Berkeley, 1945	36	RBCM, ROM	65, 98, 160, 297
Lumbrineris similabris Treadwell, 1929	2	RBCM	298
Lumbrineris zonata Johnson, 1901	4	RBCM	298
Ninoe gemmea Moore, 1911	10	RBCM, ROM	98
Paraninoe simpla (Moore, 1905)	4	ROM	98, 160
Family Oenonidae			
Oenonidae	4		98, 160
Arabella iricolor (Montagu, 1804)	11	CAS, RBCM	297, 298
Drilonereis falcata minor Hartman, 1965	7	ROM	98
Drilonereis cf. *falcata minor* Hartman, 1965	1	ROM	98
Drilonereis filum (Claparède, 1870)	1	RBCM	
Drilonereis longa Webster, 1879	3	ROM	98
Family Onuphidae			
Onuphidae	18	RBCM, ROM	98
Diopatra ornata Moore, 1911	1	RBCM	
Epidiopatra hupferiana Day, 1960	1		47
Nothria conchylega (Sars, 1835)	9	ROM	98
Nothria pallida Moore, 1911	3		7
Onuphis sp.	7	RBCM, ROM	98
Onuphis elegans (Johnson, 1901)	3	ROM	98
Onuphis geophiliformis (Moore, 1903)	24	ROM	23, 98
Onuphis iridescens Johnson, 1901	28	RBCM, ROM	23, 98, 298
Sarsonuphis parva (Moore, 1911)	1	CMN	
Suborder Phyllodocida			
Family Alciopidae			
Alciopidae	1	RBCM	
Naiades cantrainii delle Chiaje, 1830	1		295
Plotohelmis tenuis (Apstein, 1900)	4	USNM	55, 295
Rhynchonerella sp.	1	RBCM	
Rhynchonerella angelina (Kinberg, 1866)	3		56, 295
Rhynchonerella mobii (Apstein, 1893)	1		295

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Aphroditidae			
Aphrodita sp.	6	RBCM	95, 311
Aphrodita japonica Marenzeller, 1885	6	CMN, RBCM	18
Aphrodita negligens Moore, 1905	1	CMN	
Family Chrysopetalidae			
Paleanotus bellis (Johnson, 1897)	6	ROM	98
Family Glyceridae			
Glyceridae	9	RBCM, ROM	98, 160
Glycera sp.	13	RBCM	23, 297, 298
Glycera americana Leidy, 1855	19	RBCM, ROM	98, 298
Glycera capitata Örsted, 1843	44	CMN, ROM	23, 49, 50, 65, 66, 98, 147, 160
Glycera robusta Ehlers, 1868	4	RBCM	49, 50, 298
Glycera oxycephala Ehlers, 1887	6	RBCM	98, 297
Hemipodus borealis Johnson, 1901	23	RBCM, ROM	50, 98, 298
Family Goniadidae			
Glycinde sp.	1	RBCM	
Glycinde armigera Moore, 1911	17	ROM	49, 65, 98
Glycinde picta Berkeley, 1927	7	RBCM	49, 50, 291
Goniada sp.	2	ROM	98
Goniada brunnea Treadwell, 1906	13	ROM	98
Goniada maculata Örsted, 1843	14	RBCM, ROM	98, 297
Family Hesionidae			
Hesionidae	2	ROM	98
Kefersteinia cirrata (Keferstein, 1863)	2		[illegible], 50
Micropodarke dubia (Hessle, 1925)	13	ROM	98
Ophiodromus pugettensis (Johnson, 1901)	17	RBCM, USNM	50, 268, 297, 298
Family Iospilidae			
Phalocrophorus pictus Greef, 1879	1		56
Family Nephtyidae			
Nephtyidae	6	RBCM, ROM	98
Aglaophamus rubella anops Hartman, 1950	1	ROM	98
Nephtys sp.	22	ROM	65, 66, 98, 160, 268, 291
Nephtys assignis Hartman, 1950	6	CMN, RBCM, ROM	98
Nephtys caeca (Fabricius, 1780)	12	CMN, ROM	50, 98
Nephtys caecoides Hartman, 1938	6	CMN, RBCM, ROM	49, 98
Nephtys californiensis Hartman, 1938	20	ROM, USNM	98
Nephtys cf. californiensis Hartman, 1938	10	ROM	98
Nephtys ciliata (Müller, 1776)	7	ROM	49, 50, 98
Nephtys cornuta Berkeley & Berkeley, 1945	4	CMN	291
Nephtys cornuta franciscana Clarke & Jones, 1955	2	ROM	98
Nephtys ferruginea Hartman, 1940	22	RBCM, ROM	98, 298
Nephtys longosetosa Örsted, 1843	20	ROM	98
Nephtys punctata Hartman, 1938	8	RBCM, ROM	98, 160
Nephtys rickettsi Hartman, 1938	3	ROM	98, 160
Family Nereididae			
Nereidae	2	RBCM, ROM	98
Ceratonereis paucidentata (Moore, 1903)	2	USNM	297
Cheilonereis cyclurus Harrington, 1897	13	RBCM, USNM	297, 298
Micronereis nanaimoensis Berkeley & Berkeley, 1953	1		65

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Neanthes sp.	1		11
Neanthes virens (Sars, 1835)	1	CMN	
Nereis sp.	10	CMN, RBCM, ROM	98, 268, 297, 298
Nereis eakini Hartman, 1936	3		49, 50
?Nereis limnicola Johnson, 1903	7	RBCM	298
Nereis pelagica (Linnaeus, 1758)	10	RBCM, USNM	49, 50, 271, 297
Nereis cf. *pelagica* (Linnaeus, 1758)	2	CMN	
Nereis procera Ehlers, 1868	9	ROM	65, 98, 297
Nereis vexillosa Grube, 1851	25	CMN, RBCM, USNM	49, 50, 160, 271, 296, 297
Nereis zonata Mälmgren, 1867	20	CMN, ROM	98
Platynereis sp.	2	CMN	
Platynereis bicanaliculata (Baird, 1863)	11	CMN, RBCM, USNM	49, 50, 297
Family Pholoidae			
Pholoe caeca Uschaekov, 1950	27	RBCM, ROM	53, 98, 160, 298
Pholoides asperus Johnson, 1897	9	ROM	98
Family Phyllodocidae			
Phyllodocidae	3	ROM	98, 160
Anaitides sp.	1	RBCM	
Anaitides groenlandica Örsted, 1843	21	ROM	98, 160
Anaitides maculata (Linnaeus, 1767)	1	USNM	
Anaitides madeirensis (Langerhans, 1880)	1	USNM	
Anaitides mucosa (Örsted, 1843)	12	ROM	98
Eteone sp.	4	ROM	66, 98
Eteone longa (Fabricius, 1870)	19	ROM	98, 160
Eteone pacifica Hartman, 1936	2	RBCM	297
Eulalia sp.	2	ROM	98
Eulalia bilineata (Johnston, 1840)	4	ROM	98
Eulalia levicornuta Moore, 1909	2		98
Eulalia nigrimaculata Moore, 1909	3	RBCM	298
Eulalia sanguinea (Örsted, 1843)	39	ROM	98, 271
Eulalia sigeformis unk	1	ROM	98
Eulalia viridis (Linnaeus, 1767)	3	ROM	98, 271
Hesionura coineaui difficilis (Banse, 1963)	7	ROM	98
Phyllodoce sp.	6	ROM	65, 98
Phyllodoce castanea (Marenzeller, 1879)	3	ROM	98
Phyllodoce citrina Mälmgren, 1865	1		98
Phyllodoce multiseriata Rioja, 1941	1	ROM	98
Phyllodoce polynoides (Moore, 1909)	5	RBCM, USNM	49, 50, 98
Family Pilargidae			
Pilargis berkeleyi Monro, 1933	1		98
Family Pisionidae			
Pisione remota (Southern, 1919)	2		98
Family Polynoidae			
Polynoidae	44	RBCM, ROM	98, 160, 297, 298
Arcteobia spinelytris Ushakov, 1955	2	ROM	98
Arctonoe fragilis (Baird, 1863)	4	CMN, RBCM	49
Arctonoe pulchra (Johnson, 1897)	3	RBCM	49, 50

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Arctonoe vittata (Grube, 1855)	6	CMN, RBCM	49, 298
Byglides macrolepidus (Moore, 1905)	2		18
Eunoe sp.	1	ROM	98
Gattyana ciliata Moore, 1902	10	RBCM, ROM	98, 297, 298
Cattyana cirrosa (Mälmgren, 1865)	3	ROM	66, 98
Gattyana cf. *cirrosa* (Pallas, 1766)	1		65
Gaudichaudius iphionelloides (Johnson, 1901)	4	RBCM	298
Halosydna brevisetosa Kinberg, 1855	17	CMN, RBCM	49, 65, 271, 297, 298
Harmothoe sp.	4	CMN, RBCM, ROM	98, 297
Harmothoe extenuata Grube, 1840	12	RBCM	49, 50, 65, 66, 298
Harmothoe fragilis (Moore, 1910)	4	RBCM	298
Harmothoe imbricata (Linnaeus, 1769)	22	RBCM	49, 50, 65, 271, 297, 298
Harmothoe lunulata (Delle Chiaje, 1841)	11	RBCM, ROM	98, 297, 298
Harmothoe cf. *lunulata* (Delle Chiaje, 1841)	1	ROM	98
Harmothoe multisetosa (Moore, 1902)	8	CMN, RBCM	50, 54, 298
Hololepida magna Moore, 1905	3	RBCM	297
Lepidasthenia berkeleyae Pettibone, 1948	1	ROM	98
Lepidonotus squamatus (Linnaeus, 1767)	20	RBCM, ROM	23, 53, 98, 297, 298
Macellicephala sp.	1	RBCM	
Polyeunoa tuta Grube, 1855	4	RBCM	49, 298
Polynoe canadensis (McIntosh, 1874)	4	ROM	98, 160
?Tenonia priops Hartman, 1961	2	RBCM	297
Family Sigalionidae			
Sigalionidae	2	ROM	98
Ehlersileanira sp.	1		48
Neoleanira areolata (McIntosh, 1885)	1	RBCM	
Sigalion sp.	5		98
Sthenelais berkelyi Pettibone, 1971	2	ROM, USNM	98
Sthenelais tertiaglabra Moore, 1910	3	ROM	18, 57, 98
Thalenessa sp.	1	ROM	98
Thalenessa spinosa (Hartman, 1939)	1	RBCM	
Family Sphaerodoridae			
Sphaerodoridium sp.	1	ROM	98
Family Syllidae			
Syllidae	11	RBCM, ROM	23, 98, 160
Autolytus sp.	7	ROM	98
Dioplosyllis sp.	4	ROM	98
Eusyllis blomstrandi Mälmgren, 1867	1	ROM	98
Eusyllis magnifica (Moore, 1906)	1		54
Exogone sp.	4	RBCM, ROM	98
Exogone lourei Berkeley & Berkeley, 1938	12	ROM	98
Haplosyllis sp.	5	RBCM	298
Odontosyllis sp.	2	RBCM, ROM	98
Odontosyllis phosphorea Moore, 1909	10	ROM, USNM	49, 65, 98
Pionosyllis uraga Imajima, 1966	1	ROM	98
Sphaerosyllis brandhorsti Hartman-Schroeder, 1965	3	ROM	98
Sphaerosyllis cf. *pirifera* Claparède, 1868	1	ROM	98
Streptosyllis sp.	1		98

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Syllis sp.	13	ROM	65, 98
Syllis alternata Moore, 1908	24	ROM	98
Syllis elongata (Johnson, 1901)	15	ROM, USNM	36, 50, 65, 66, 98, 271
Syllis fasciata Mälmgren, 1867	2		49, 271
?Syllis gracilis Grube, 1840	3	RBCM	298
Syllis heterochaeta Moore, 1909	1	ROM	98
Syllis hyalina Grube, 1863	21	ROM	98
Syllis pulchra Berkeley & Berkeley, 1938	4	RBCM, USNM	36, 50, 271
Syllis stewarti Berkeley & Berkeley, 1942	3	RBCM	50, 271
Trypanosyllis gemmipara Johnson, 1901	1	USNM	
Family Tomopteridae			
Tomopteris sp.	8	RBCM	142
Tomopteris cavalli Rosa, 1908	3		55
Tomopteris septentrionalis Steenstrup, 1849	1		49
Family Typhloscolecidae			
Travisiopsis lobifera Levinson, 1885	2	RBCM	56
Typholoscolex meulleri Busch, 1851	3		56
Suborder Aciculata *incertae sedis*			
Family Aberrantidae			
Sinistrella verruca (Fabricius, 1780)	1		54
Sinistrella cf. *verruca* (Fabricius, 1780)	1		65
Order Canalipalpata			
Suborder Sabellida			
Family Oweniidae			
Oweniidae	1	ROM	98
Myriochele sp.	1		98
Myriochele oculata Zachs, 1923	99	ROM	98, 160, 291
Myriochele cf. *oculata* Zachs, 1923	27	ROM	98
Owenia collaris Hartman, 1955	31	RBCM, ROM	23, 98, 160, 297, 298
Family Sabellariidae			
Idanthyrsus armatus Kinberg, 1867	2	CMN	54
Idanthyrsus ornamentatus Chamberlin, 1919	15	ROM	98
Sabellaria cementarium Moore, 1906	5	ROM	16, 98
Family Sabellidae			
Sabellidae	33	RBCM, ROM	22, 98, 298
Chone sp.	4	ROM	13, 98
Chone duneri Mälmgren, 1867	18	ROM	98
Chone ecaudata (Moore, 1923)	22	ROM	98
Chone infundibuliformis Kröyer, 1856	2		52, 271
Euchone sp.	1	ROM	98
Euchone analis (Kröyer, 1956)	17		98
Euchone cf. *analis* (Kröyer, 1956)	17	ROM	98
Euchone arenae Hartman, 1966	4	ROM	98
Euchone incolor Hartman, 1965	4	ROM	53, 98
Eudistylia sp.	2		19, 161
Eudistylia catharinae Banse, 1979	1		98
Eudistylia polymorpha (Johnson, 1901)	1		18
Eudistylia vancouveri (Kinberg, 1867)	8		52, 271, 275, 276
Fabricia oregonia Banse, 1956	1		291

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Jasmineira pacifica Annenkova, 1937	4	RBCM, ROM	98, 297
Megalomma splendida (Moore, 1905)	9	ROM	23, 98
Myxicola sp.	2		10, 22
Myxicola aesthetica Claparède, 1870	3	RBCM	298
Potamilla occellata (Moore, 1905)	1		268
Sabella crassicornis Sars, 1851	2	RBCM	297
Sabella pacifica Berkeley & Berkeley, 1954	2		98
Schizobranchia insignis Bush, 1904	2		51, 52
Family Serpulidae			
Serpulidae	12	RBCM	22, 23
Circeis amoricana Saint-Joseph, 1894	1		200
Crucigera sp.	1		22
Crucigera irregularis Bush, 1904	6	RBCM, ROM	18, 98
Crucigera zygophora (Johnson, 1901)	3	ROM	98
Paradexiospira violacea (Levinsen, 1883)	1		100
Paradexiospira vitrea (Fabricius, 1780)	1		52
Pileolaria potswaldi Knight-Jones, 1978	2		52, 100
Protula pacifica Pixell, 1912	2	RBCM	298
Pseudochitinopoma occidentalis Bush, 1909	5	ROM	98
Salmacina tribranchiata (Moore, 1923)	1		8
Serpula columbiana Johnson, 1901	124	CMN, RBCM, USNM	9, 10, 13, 16, 20, 22, 160, 161, 268, 271, 275, 276, 297, 298
Spirorbis sp.	68	RBCM, ROM	12, 98, 160, 161, 268, 297, 298
Spirorbis bifurcatus Knight-Jones, 1978	5	RBCM	297, 298
Suborder Spionida			
Family Apistobranchidae			
Apistobranchus ornatus Hartman, 1965	3	ROM	98
Family Chaetopteridae			
Chaetopteridae	5	RBCM, ROM	98
Mesochaetopterus taylori Potts, 1914	1	ROM	98
Phyllochaetopterus sp.	7	ROM	98
Phyllochaetopterus prolifica Potts, 1914	3		22, 160
Spiochaetopterus sp.	1		65
Spiochaetopterus costarum (Claparède, 1868)	41	RBCM, ROM	98, 298
Family Magelonidae			
Magelonidae	1	ROM	98
Magelona sp.	2	ROM	56, 98
Magelona hobsonae Jones, 1978	16	ROM	98
Magelona longicornis Johnson, 1901	26	ROM	98, 160
Magelona sacculata Hartman, 1961	7	ROM	98
Family Spionidae			
Spionidae	4	RBCM, ROM	98, 160, 298
Aonides sp.	6	ROM	98
Laonice cirrata (Sars, 1850)	15	ROM, USNM	52, 65, 66, 98, 281
Laonice pugettensis Banse & Hobson, 1968	4	CMN, RBCM	298
Malacoceras glutaeus (Ehlers, 1897)	1	ROM	98
Paraprionospio pinnata (Ehlers, 1901)	3	RBCM	298

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Polydora sp.	3	ROM, USNM	98
Polydora brachycephala Hartman, 1936	17	ROM	98
Polydora cardalia Berkeley, 1927	6	ROM	98
Polydora giardi Mesnil, 1896	2		98
Polydora pugettensis Blake, 1979	1	ROM	98
Polydora socialis (Schmarda, 1861)	17	ROM	98
Prionospio multibranchiata Berkeley, 1927	12	ROM	98
Prionospio steenstrupi Mälmgren, 1867	60	CMN, RBCM, ROM	98, 160, 291, 297, 298
Pygospio elegans Claparède, 1863	1		13
Scolelepis squamata (Müller, 1806)	4	ROM	98, 160
Spio sp.	29	ROM	98
Spio butleri Berkeley & Berkeley, 1954	1	USNM	
Spio cf. *butleri* Berkeley & Berkeley, 1954	2	ROM	53, 98
Spio cirrifera (Banse & Hobson, 1968)	1	ROM	98
Spio filicornis (Müller, 1776)	11	ROM	98
Spio cf. *filicornis* (Müller, 1776)	6	ROM	98
Spiophanes berkeleyorum Pettibone, 1962	40	ROM	98, 160
Spiophanes bombyx (Claparède, 1870)	39	ROM	98
Family Trochochaetidae			
Trochochaeta sp.	2	RBCM	297
Suborder Terebellida			
Family Ampharetidae			
Ampharetidae	8	RBCM, ROM	98
Amage anops (Johnson, 1901)	13	ROM	98
Ampharete sp.	16	ROM	98, 160
Ampharete acutifrons (Grube, 1860)	31	ROM	98
Ampharete finmarchica (Sars, 1865)	28	CMN, ROM	98
Amphicteis sp.	2	ROM	98
Amphicteis mucronata Moore, 1923	3	CMN	49, 52
Amphicteis scaphobranchiata Moore, 1906	3	RBCM, ROM	98
Anobothrus gracilis (Mälmgren, 1866)	5	ROM	98
Asabellides lineata (Berkeley & Berkeley, 1943)	2	ROM	98
Lysippe labiata Mälmgren, 1866	22	ROM	98
Melinna cristata (Sars, 1851)	5	ROM	98
Melinna elisabethae McIntosh, 1922	2	ROM	98
Schistocomus hiltoni Chamberlin, 1919	5	ROM	98
Family Cirratulidae			
Cirratulidae	18	ROM	98
Aphelochaeta multifilis (Moore, 1909)	1	ROM	98
Aphelochaeta parvus (Berkeley, 1929)	1		291
Caulleriella bioculata (Keferstein, 1862)	8		98
Caulleriella cf. *bioculata* (Keferstein, 1862)	4	ROM	98
Caulleriella hamata (Hartman, 1948)	4	ROM	98
Caulleriella oculata unk	3		98
Caulleriella cf. *oculata* unk	1	ROM	98
Chaetozone sp.	11	ROM	98
Chaetozone acuta Banse & Hobson, 1968	10	RBCM, ROM	98, 298
Chaetozone setosa Mälmgren, 1867	33	ROM	98
Chaetozone cf. setosa Mälmgren, 1867	1		65
Chaetozone spinosa Moore, 1903	16	ROM	98

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Cirratulus sp.	4	RBCM	297
Cirratulus cirratus Müller, 1776	12	RBCM, ROM, USNM	49, 51, 52, 98, 297
Cirratulus spectabilis (Kinberg, 1866)	2		52, 297
?Cirriformia spirabrancha (Moore, 1904)	1		297
Dodecaceria concharum Örsted, 1843	24		9, 10, 11, 160
Dodecaceria fewkesi Berkeley & Berkeley, 1954	27	RBCM	10, 14, 16, 20, 54, 160, 161, 298
Monticellina tesselata (Hartman, 1960)	16	ROM	98
Tharyx sp.	18	ROM	98
Family Flabelligeridae			
Flabelligeridae	2	RBCM	98
Brada villosa (Rathke, 1843)	3	ROM	98
Diplocirrus sp.	8	ROM	98
Flabelligera affinis Sars, 1829	1	CMN	
Pherusa negligens Berkeley & Berkeley, 1950	1	ROM	98
Pherusa plumosa Müller, 1776	10	RBCM, ROM	49, 52, 98, 297, 298
Piromis eruca Claparède, 1870	18	RBCM	
Family Pectinariidae			
Pectinariidae	1	RBCM	
Pectinaria sp.	7	RBCM	65, 66
Pectinaria californiensis Hartman, 1941	20	ROM	49, 52, 98
Pectinaria granulata Linnaeus, 1767	10	CMN, RBCM, ROM	98
Family Sternaspidae			
Sternaspis sp.	2	RBCM	305
Sternaspis fossor Stimpson, 1854	3	CMN	65, 66
Sternaspis scutata Renier, 1807	39	RBCM, ROM	18, 98, 160
Family Terebellidae			
Terebellidae	31	RBCM, ROM	23, 98, 160
Amphitrite cirrata (Müller, 1771)	6		49, 52, 65
Artacama coniferi Moore, 1905	16	ROM	65, 66, 98, 160
Artacamella hancocki Hartman, 1955	12	ROM	98
Eupolymnia heterobranchia Johnson, 1901	4	RBCM	51, 52, 298
Neoamphitrite edwardsi (Quatrefages, 1865)	1	RBCM	
Neoamphitrite robusta Johnson, 1901	8	RBCM	49, 52, 98, 298
Neoleprea spiralis (Johnson, 1901)	2	RBCM	37, 52
Nicolea zostericola Örsted, 1844	4	RBCM	52, 98, 298
Pista brevibranchiata Moore, 1923	20	ROM	98
Pista cristata (Müller, 1776)	30	ROM	98
Pista elongata Moore, 1909	2	ROM	98
Pista cf. *fasciata* (Grube, 1870)	1		65
Pista gibbauncinata Saphronova, 1984	1		272
Pista moorei Berkeley & Berkeley, 1942	1	ROM	98
Pista pacifica Berkeley, 1942	2	RBCM	297
Polycirrus sp.	10	ROM	98
Polycirrus californicus Moore, 1909	6	ROM	98
Polycirrus sp. complex Banse, 1980	58	CMN, ROM	98, 160
Polycirrus sp. III Banse, 1980	6	ROM	98
Proclea cf. *emmi* Annenkova, 1937	1	ROM	98
Scionella estevanica (Berkeley & Berkeley, 1942)	19	ROM	98
Scionella japonica Moore, 1903	2		21, 23

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Streblosoma bairdi (Mälmgren, 1866)	2	ROM	98
Thelepus cincinnatus (Fabricius, 1780)	7	ROM	98
Thelepus crispus Johnson, 1901	6	RBCM	49, 52, 271, 298
Thelepus japonica (Merenzeller, 1884)	2	ROM	98
Family Trichobranchidae			
Terebellides stroemi Sars, 1835	30	ROM	98, 291
Terebellides cf. *stroemi* Sars, 1835	1		65
Trichobranchus glacialis Mälmgren, 1866	3	ROM	98
Suborder Canalipalpata incertae sedis			
Family Polygordiidae			
Polygordiidae	2	ROM	98
Polygordius sp.	9	ROM	98
Family Protodrilidae			
Protodrilidae	1		13
Family Saccocirridae			
Saccocirrus eroticus Gray, 1969	1	ROM	98
Phylum Echiura			
Order Bonelloinea			
Family Bonelliidae			
Bonelliidae	3	RBCM	
Order Echiuroinea			
Family Echiuridae			
Echiuridae	1	RBCM	
Arhynchite sp.	2	RBCM	65
Arhynchite californicus Fisher, 1949	24	RBCM	
Echiurus echiurus Fisher, 1946	5	MCZ, RBCM, ROM, USNM	18, 98, 151
Echiurus echiurus alaskanus Fisher, 1946	1	USNM	
Order Xenopneusta			
Family Urechidae			
?*Urechis caupo* Fisher & MacGinitie, 1928	2		268

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Phylum Sipuncula (Peanut Worms)			
Order Sipunculida			
Family Golfingiidae			
Golfingia sp.	13	CMN, RBCM, ROM	23, 98
Golfingia margaritacea Sars, 1851	31	CMN, RBCM, ROM	98, 153, 281
Golfingia mobius Mobius, 1875	1	RBCM	
Golfingia vulgaris Blainville, 1827	3	RBCM	98, 297
Golfingia cf. vulgaris Blainville, 1827	1	ROM	98
Nephasoma capelliformis (Murina, 1973)	2		246
Nephasoma diaphanes (Gerould, 1913)	2	ROM	23, 98
Nephasoma eremita (Sars, 1851)	6	RBCM	
Nephasoma wodjanizkii (Murina, 1973)	1		246
Themiste sp.	1	RBCM	
Themiste pyroides (Chamberlain, 1920)	2	RBCM	298
Thysanocardia pugettensis (Ikeda, 1904)	1	RBCM	
Family Phascolosomatidae			
Phascolosoma sp.	16	CMN, RBCM	153
Phascolosoma agassizi Keferstein, 1867	77	RBCM, USNM	9, 10, 12, 13, 16, 108, 153, 160, 268, 297, 298
Family Sipunculidae			
Sipunculus sp.	5	ROM	95, 98, 268
Phylum Pogonophora (Beard Worms)			
Order Athecanephria			
Family Siboglinidae			
Siboglinum sp.	1		287
Siboglinum fedotovi Ivanov, 1957	2		287
Siboglinum pusillum Ivanov, 1960	3		287
Order Thecanephria			
Family Lamellisabellidae			
Lamellisabella coronata Southward, 1969	1		287
Family Polybrachiidae			
Galathealinum brachiosum Ivanov, 1961	1		287
Polybrachia canadensis (Ivanov, 1962)	4		187, 287

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Phylum Mollusca (Snails, Clams, Chitons, Sea Slugs, Squids)			
Class Aplacophora			
Subclass Caudofoveata			
Order Chaetodermatida			
Family Chaetodermatidae			
Chaetoderma sp.	8	ROM	30, 98
Subclass Solenogastres			
Order Neomeniamorpha			
Family Neomeniidae			
Neomenia cf. yamamoitoi Baba, 1975	1		
Class Polyplacophora			
Order Neoloricata			
Suborder Lepidopleurina			
Family Hanleyidae			
Hanleya oldroydi Dall, 1919	2	RBCM	
Family Lepidopleuridae			
Leptochiton alveolus (Lovén, 1846)	4	CAS, RBCM, USNM	130, 149, 203
Leptochiton cf. alveolus (Lovén, 1846)	1	RBCM	
Leptochiton rugatus (Pilsbry, 1892)	11	LACM, RBCM	23, 149, 160, 297
Suborder Chitonina			
Family Chaetopleuridae			
Chaetopleura gemma *Dall, 1879*	2	RBCM, ROM	98
Family Ischnochitonidae			
Ischnochitonidae	5	RBCM, ROM	98, 268
Basiliochiton sp.	1	RBCM	
Ischnochiton sp.	16	RBCM, ROM	98
Ischnochiton abyssicola Smith & Cowan, 1966	1	CAS	285
Ischnochiton interstinctus (Gould, 1846)	17	CMN, RBCM	248, 297, 298, 305
Ischnochiton trifidus Carpenter 1864	9	CMN, RBCM	305
Lepidochiton hartwegi (Carpenter, 1855)	2	CMN	305
Lepidochitona sp.	2	RBCM	
Lepidochitona dentiens (Gould, 1846)	24	CAS, RBCM	69, 248, 271, 297, 298
Lepidochitona fernaldi Eernisse, 1986	10	RBCM	297, 298
Lepidochitona flectens (Carpenter, 1864)	4	CAS, ROM	69, 98, 150
Lepidozona sp.	29	RBCM	
Lepidozona mertensi (Middendorff, 1847)	23	CMN, LACM, RBCM, ROM	68, 69, 98, 148, 160, 297, 298, 305
Lepidozona retiporosus (Carpenter, 1864)	8	CAS, RBCM	
Lepidozona willetti (Berry, 1917)	7	RBCM	297
Schizoplax brandti (Middendorff, 1847)	1		69

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Tonicella insignis (Reeve, 1847)	15	CAS, RBCM	69, 268, 297, 298
Tonicella lineata (Wood, 1815)	118	CMN, RBCM	8, 13, 65, 69, 160, 161, 268, 271, 275, 276, 297, 298, 306
Tonicella marmorea (Fabricius, 1780)	1		305
Tonicella submarmorea (Middendorff, 1846)	2	RBCM	248
Family Mopaliidae			
Dendrochiton sp.	2	RBCM	
Dendrochiton semiliratus Berry, 1927	3	RBCM	298
Katharina tunicata (Wood, 1815)	89	CMN, MCZ, RBCM	8, 10, 69, 160, 161, 268, 271, 275, 276, 297, 298, 305
Mopalia sp.	20	CAS, RBCM	160, 161, 268, 271
Mopalia ciliata (Sowerby, 1840)	21	CAS, CMN, RBCM	9, 69, 160, 271, 305
Mopalia cirrata Berry, 1919	3	RBCM	69
Mopalia egretta Berry, 1919	1		68
Mopalia ferreirai Clark, 1991	2		112
Mopalia hindsii (Reeve, 1847)	3	RBCM	69
Mopalia imporcata Carpenter, 1864	1	CMN	
?*Mopalia laevior* Pilsbry, 1918	1	RBCM	
Mopalia lignosa (Gould, 1846)	32	CAS, CMN, RBCM	10, 69, 160, 268, 271, 297, 298
Mopalia muscosa (Gould, 1846)	35	CAS, RBCM	10, 16, 69, 160, 268, 275, 276, 297
Mopalia phorminx Berry, 1919	1	RBCM	
Mopalia spectabilis Cowan & Cowan, 1977	2	RBCM	230
Mopalia swanii Carpenter, 1864	3	CMN	69
Placiphorella sp.	6	CMN, RBCM	24
Placiphorella pacifica Berry, 1919	4	LACM	284
Placiphorella rufa Berry, 1917	1		68
Placiphorella velata Dall, 1879	17	CAS, RBCM	9, 10, 160
Suborder Acanthochitonida			
Family Acanthochitonidae			
Cryptochiton sp.	1		260
Cryptochiton stelleri (Middendorff, 1847)	73	CMN, RBCM	11, 13, 16, 69, 160, 161, 193, 268, 271, 275, 276, 305
Class Gastropoda			
Subclass Prosobranchia			
Order Archaeogastropoda			
Suborder Pleurotomariina			
Family Fissurellidae			
Arginula sp.	1	RBCM	
Arginula bella (Gabb, 1865)	3	RBCM	9
Craniopsis cucullata Gould, 1846	14	CMN, LACM, RBCM	305
Craniopsis decorata Cowan & Mclean, 1968	7	CAS, CMN, LACM, RBCM, USNM	234
Craniopsis major Dall, 1891	1		135
Craniopsis multistriata Dall, 1914	5		CMN, LACM, RBCM
Diodora aspera (Rathke, 1833)	55	CMN, LACM, RBCM, USNM	8, 9, 10, 11, 12, 160, 268, 275, 276, 297, 298, 305
Emarginula crassa Sowerby, 1812	1	CMN	
Fissurellidea bimaculata (Dall, 1871)	11	CMN, LACM	9, 10, 12, 160, 268, 305

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Fissurisepta pacifica Cowan, 1969	1	CMN	232
Puncturella sp.	4	RBCM	
Puncturella cooperi Carpenter, 1864	8	LACM, RBCM	
Puncturella galeata (Gould, 1846)	15	CMN, LACM, RBCM, ROM	23, 98, 305
Family Haliotidae			
Haliotidae	1	RBCM	
Haliotis kamtschatkana Jonas, 1845	108	CMN, FLMNH, LACM, RBCM	1, 8, 9, 10, 11, 12, 13, 14, 16, 20, 29, 160, 161, 193, 237, 238, 268, 275, 276, 298, 305, 310
Family Scissurellidae			
Anatoma sp.	1	RBCM	
Anatoma crispata (Flemming, 1832)	3	RBCM, USNM	221, 253
Suborder Trochina			
Family Cocculinidae			
Cocculina baxteri McLean, 1987	1		135
Cocculina cowani McLean, 1987	5	CAS, CMN, LACM, NMNZ, USNM	224
Family Trochidae			
Trochidae	4	RBCM	297
Bathybembix sp.	1		24
Bathybembix bairdii (Dall, 1889)	2	LACM	
Bathybembix cidaris (Adams, 1864)	31	ANSP, CMN, LACM, RBCM	8, 18, 95
Calliostoma sp.	13	RBCM	10, 268
Calliostoma annulatum (Lightfoot, 1786)	29	CMN, LACM, RBCM	8, 12, 16, 160, 276
Calliostoma canaliculatum (Lightfoot, 1786)	22	CMN, LACM, RBCM	8, 12, 160, 238, 305
Calliostoma ligatum (Gould, 1849)	78	CMN, LACM, RBCM	10, 12, 160, 161, 268, 275, 276, 297, 298, 305
Calliostoma platinum Dall, 1890	4	LACM, RBCM	23, 231
Calliostoma variegatum Carpenter, 1864	5	RBCM	
Calliotropis carlotta (Dall, 1902)	1	USNM	130
Halistylus sp.	1	RBCM	
Halistylus pupoideus (Carpenter, 1864)	3	RBCM	248, 305
Lirularia sp.	4		160, 296, 297
Lirularia lirulata (Carpenter, 1864)	11	CMN, LACM, RBCM	297, 298, 305
Lirularia parcipicta (Carpenter, 1864)	7	LACM, RBCM	297
Lirularia succincta (Carpenter, 1864)	11	CMN, LACM, RBCM	268, 297
Margarites sp.	8	RBCM	98, 296, 297
Margarites beringensis (Smith, 1899)	4	RBCM	297
Margarites helicinus (Phipps, 1774)	11	CMN, LACM, RBCM, ROM	98, 305
Margarites inflatulus Dall, 1919	10	LACM, RBCM	297, 298
Margarites marginatus Dall, 1919	4		160
Margarites pupillus (Gould, 1841)	30	CMN, LACM, RBCM, ROM	98, 160, 174, 297, 298, 305
Solariella sp.	2	RBCM	9

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Solariella nuda Dall, 1896	1		24
Solariella obscura (Couthouy, 1838)	4	LACM, RBCM	
Solariella peramabilis Carpenter, 1864	47	ANSP, CMN, LACM, RBCM, ROM	18, 19, 98
Solariella varicosa (Mighels & Adams, *1842)*	2	CMN, RBCM	
Tegula sp.	5	RBCM	238
Tegula funebralis (Adams, 1855)	6		21, 268
Tegula marcida Gould, 1853	1	CMN	
Tegula pulligo (Gmelin, 1791)	98	CMN, LACM, RBCM	9, 12, 14, 20, 160, 275, 276, 298, 305
Family Turbinidae			
Turbinidae	1	RBCM	
Homalopoma sp.	1	RBCM	298
Homalopoma carpenteri Pilsbry, 1888	8	CMN, RBCM	
Homalopoma lacunatum (Carpenter, 1864)	7	RBCM	160, 231, 297
Homalopoma luridum (Dall, 1885)	37	LACM, RBCM	65, 66, 160, 297, 298
Homalopoma subobsoletum Willett, 1937	4	LACM, RBCM	297
Leptothyra sp.	1	RBCM	
Lithopoma gibberosum (Dillwyn, 1817)	96	CMN, LACM, RBCM	1, 10, 12, 14, 16, 20, 100, 160, 237, 238, 268, 275, 276, 297, 298
Spiromoelleria quadrae (Dall, 1897)	1		128, 248, 253
Tricolia lurida Dall, 1897	3	CMN, USNM	128, 248
Tricolia pulloides (Carpenter, 1865)	3	RBCM	248
Order Patellogastropoda			
Suborder Nacellina			
Family Acmaeidae			
Acmaeidae	25	RBCM, ROM	98
Acmaea sp.	13	CMN, RBCM	268
Acmaea mitra Rathke, 1833	105	CMN, LACM, RBCM	9, 13, 160, 161, 238, 268, 271, 275, 276, 296, 297, 298, 305
Family Lepetidae			
Cryptobranchia concentrica Middendorf, 1857	2	CMN, RBCM	
Iothia lindbergi McLean, 1985	1		223
Lepeta sp.	1		23
Lepeta caeca (Müller, 1776)	20	RBCM	8
Family Lottiidae			
Lottia sp.	14	RBCM	1, 9, 268
Lottia alveus Conrad, 1831	6	RBCM	297, 298
Lottia digitalis Rathke, 1833	61	LACM, RBCM	160, 161, 268, 297
Lottia ochracea Dall, 1871	11	CMN, LACM, RBCM	16, 271, 297, 298, 305
Lottia pelta Rathke, 1833	93	CMN, LACM, RBCM	160, 268, 271, 297, 305
Lottia strigatella (Carpenter, 1864)	4	RBCM	298
Lottia triangularis Carpenter, 1864	6	RBCM	297, 298
Tectura sp.	6		268
Tectura fenestrata (Reeve, 1855)	11	RBCM	297, 298
Tectura persona (Rathke, 1833)	40	CMN, LACM, RBCM	160, 161, 238, 268, 271, 297, 305

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Tectura scutum (Rathke, 1833)	96	LACM, RBCM	10, 16, 160, 161, 238, 268, 275, 276, 297, 298
Order Mesogastropoda			
Suborder Heteropoda			
Family Atlantidae			
Atlantia sp.	1		56
Suborder Taenioglossa			
Family Caecidae			
Micranellum sp.	3	RBCM	
Micranellum crebricinctum (Carpenter, 1864)	11	CMN, RBCM, ROM	65, 98, 248, 297, 305
Family Calyptraeidae			
Calyptraeidae	1	RBCM	
Calyptraea fastigiata Gould, 1846	13	CMN, RBCM, ROM	8, 98, 305
Crepidula sp.	4	RBCM, ROM	98, 268
Crepidula adunca Sowerby, 1825	16	CMN, RBCM	65, 160, 231, 268, 305
Crepidula dorsata (Broderip, 1834)	16	CMN, RBCM, ROM	98, 174
Crepidula nummaria Gould, 1846	4	CMN, RBCM	298
Crepidula perforans (Valenciennes, 1846)	15	CMN, RBCM	160, 298, 305
Family Cerithiidae			
Bittium sp.	29	RBCM, ROM	98, 268, 297, 298
Bittium armillatum (Carpenter, 1864)	2	LACM	
Bittium attenuatum Carpenter, 1864	7	CMN, LACM, RBCM	297
Bittium eschrichtii (Middendorf, 1849)	38	CMN, LACM, RBCM	160, 161, 297, 298, 305
Bittium munitum (Carpenter, 1864)	17	CMN, RBCM	231, 297, 298
Bittium quadrifilatum Carpenter, 1864	3		248
Family Cerithiopsidae			
Cerithiopsis sp.	2	RBCM	
Cerithiopsis stejnegeri Bartsch, 1917	2	RBCM	135
Cerithiopsis tuberculatus Montagu, 1803	2	CMN	305
Family Cymatiidae			
Fusitriton oregonensis (Redfield, 1848)	53	CMN, LACM, RBCM	8, 9, 10, 16, 18, 19, 20, 259, 260, 268, 275, 276, 311
Family Cypraeidae			
Cypraeidae	1	RBCM	
Family Epitoniidae			
Boreoscala groenlandica (Perry, 1811)	3	RBCM	145, 231
Epitonium sp.	2	RBCM	
Nitidiscala sp.	2	RBCM	298
Nitidiscala catalinae (Dall, 1908)	1	LACM	145
Nitidiscala hindsii (Carpenter, 1856)	1	RBCM	
Nitidiscala indianorum (Carpenter, 1865)	11	CMN, RBCM, ROM	19, 98, 298, 305
Nitidiscala sawinae (Dall, 1903)	1	LACM	145
Opalia sp.	4	RBCM	160
Opalia borealis Keep, 1881	8	CMN, RBCM	
Opalia montereyensis (Dall, 1907)	2	CMN, RBCM	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Eulimidae			
Balcis sp.	3		98
Balcis montereyensis (Bartsch, 1917)	1	ROM	98
Eulima sp.	4	RBCM	
Melanella sp.	4	RBCM, ROM	98
Melanella micans (Carpenter, 1865)	3	RBCM, ROM	98, 293
Melanella rutila (Carpenter, 1864)	1	RBCM	
Sabinella ptilocrinicola (Bartsch, 1907)	1	USNM	43
Vitreolina columbiana (Bartsch, 1917)	1	RBCM	
Family Hipponicidae			
Hipponix cranioides Carpenter, 1864	2	CMN	231, 305
**Sabia conica* (Schumacher, 1817)	1	RBCM	233
Family Lacunidae			
Lacuna sp.	2	RBCM	160
Lacuna marmorata Dall, 1919	1	LACM	
Lacuna porrecta Carpenter, 1864	3	LACM	305
Lacuna variegata Carpenter, 1864	6	CMN, RBCM	296, 305
Lacuna vincta (Montagu, 1803)	15	CMN, LACM, RBCM	271, 297, 298
Family Littorinidae			
Littorinidae	2	RBCM	
Algamorda subrotundata (Carpenter, 1864)	3	RBCM	297, 298
Littorina sp.	19	CMN, RBCM	1, 9, 238, 268, 291
?Littorina keenae Rosewater, 1978	3	RBCM	298
Littorina plena Gould, 1849	5	LACM	267
Littorina scutulata Gould, 1849	141	CMN, LACM, RBCM	10, 16, 160, 161, 268, 271, 296, 297, 298, 305
Littorina sitkana Philippi, 1845	154	CMN, LACM, RBCM, USNM	10, 16, 160, 161, 268, 271, 275, 296, 297, 298, 305
Family Naticidae			
Naticidae	1	RBCM	
Cryptonatica affinis Gmelin, 1792	1	LACM	
Cryptonatica clausa (Broderip & Sowerby, 1829)	32	CMN, LACM, RBCM, ROM	65, 98, 297, 305
Euspira sp.	40	ROM	98, 173, 259, 260
Euspira lewisii Gould, 1847	52	CMN, LACM, ROM	1, 8, 9, 11, 13, 16, 18, 29, 98, 160, 174, 193, 259, 268, 275, 276, 29
Euspira pallidus Broderip & Sowerby, 1829	16	LACM, RBCM, ROM	18, 19, 98
Neverita nanus (Müller, 1842)	1	LACM	
Family Potamididae			
Cerithidea sp.	1	RBCM	
Family Rissoidae			
Alvania sp.	10	ROM	98
Alvania compacta (Carpenter, 1864)	6	CMN, RBCM, ROM, USNM	39, 98, 305
Barleeia sp.	2	RBCM	
Barleeia acuta Carpenter, 1864	7	CMN, RBCM	135, 248, 253, 297

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Barleeia haliotiphila Carpenter, 1864	3	RBCM	297
Boreocingula martyni (Dall, 1887)	2	RBCM	135
Onoba carpenteri (Weinkauff, 1885)	2	RBCM	305
Family Rissoinidae			
Rissoina newcombei Dall, 1897	1	RBCM	42, 128, 248
Family Trichotropidae			
Trichotropis bicarinata (Sowerby, 1825)	1		231
Trichotropis borealis Broderip & Sowerby, 1829	3	RBCM	135, 231
Trichotropis cancellata Hinds, 1849	29	CMN, LACM, RBCM, ROM	8, 9, 98, 160, 305
Trichotropis insignis Middendorff, 1849	1	RBCM	
Trichotropis kroyeri Philippi, 1849	1	LACM	
Family Turritellidae			
Tachyrhynchus sp.	1	RBCM	
Tachyrhynchus lacteolus (Carpenter, 1864)	2	RBCM	65
Tachyrhynchus reticulatis Mighels, 1842	1	LACM	
Turritellopsis sp.	1	RBCM	
Family Velutinidae			
Marsenina sp.	4		8, 10, 160
Marsenina stearnsi Dall, 1871	2	CMN	271, 305
Velutina sp.	2	RBCM	65
Velutina prolongata Carpenter, 1864	2	CMN, RBCM	
Velutina velutina (Müller, 1776)	1	LACM	
Velutella plicatilis (Müller, 1776)	6	CMN, RBCM	
Family Vermetidae			
Dendropoma lituella (Morch, 1886)	2	RBCM	297
Petaloconchus sp.	1	RBCM	297
Petaloconchus compactus (Carpenter, 1864)	18	RBCM	8, 10, 12, 13, 16, 160, 297, 298
Family Vitrinellidae			
Leptogyra sp.	1	RBCM	
Order Neogastropoda			
Suborder Rachiglossa			
Family Buccinidae			
Buccinidae	1	RBCM	
Ancistrolepis eucosmius Dall, 1891	1	LACM	
Buccinum sp.	2	RBCM	173
Buccinum baeri (Middendorf, 1848)	1	RBCM	
Buccinum cf. *baeri* Middendorf, 1848	1	RBCM	
Buccinum planeticum Dall, 1919	1		135
Buccinum plectrum Stimpson, 1865	2	RBCM	
Buccinum scalariforme Moller, 1842	4		18, 19
Buccinum strigillatum Dall, 1891	1	RBCM	
Buccinum cf. *undatum* Linnaeus, 1758	1		24
Buccinum viridum Dall, 1889	1	LACM	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Lirabuccinum sp.	15		160
Lirabuccinum dira (Reeve, 1864)	46	CMN, LACM, RBCM	8, 9, 10, 268, 269, 275, 276, 297, 298, 305
Volutharpa ampullacea (Middendorff, 1848)	1	RBCM	
Family Columbellidae			
Alia sp.	4	RBCM	298
Alia carinata (Hinds, 1844)	17	RBCM	160, 297, 298
Alia tuberosa (Carpenter, 1864)	6	RBCM	298
Amphissa sp.	30	RBCM	9, 23, 268
Amphissa bicolor Dall, 1892	1	RBCM	
Amphissa columbiana Dall, 1916	68	CMN, LACM, RBCM, ROM	9, 65, 66, 98, 160, 268, 297, 298
Amphissa corrugata Reeve, 1847	4	CMN	305
Amphissa reticulata Dall, 1916	15	LACM, RBCM	
Amphissa versicolor Dall, 1871	25	CMN, LACM, RBCM, ROM	98, 231, 297, 298, 305
Astyris gausapata (Gould, 1851)	34	CMN, RBCM, ROM	65, 66, 98, 297, 305
Astyris tuberosa (Carpenter, 1864)	1	CMN	
Mitrella sp.	11	RBCM	
Family Fusinidae			
Fusinus sp.	2	RBCM	
Fusinus harfordii (Stearns, 1871)	6	RBCM	160, 305
Family Marginellidae			
Granulina margaritula (Carpenter, 1857)	10	CMN, RBCM	268, 298, 305
Marginella sp.	1	RBCM	
Family Muricidae			
Muricidae	3	RBCM	160
Boreotrophon clathratus (Linnaeus, 1767)	1	CMN	
Boreotrophon orpheus (Gould, 1849)	5	CMN, LACM, RBCM	297, 305
Boreotrophon stuarti (Smith, 1880)	5	LACM, RBCM	
Ceratostoma sp.	2		259, 268
Ceratostoma foliatum (Gmelin, 1791)	42	CMN, LACM, RBCM	1, 8, 10, 160, 161, 238, 268, 275, 297, 298, 305
Ocenebra sp.	1		268
Ocenebra interfossa Carpenter, 1864	19	CMN, LACM, RBCM	160, 268, 275, 297, 305
Ocenebra lurida (Middendorf, 1849)	15	CMN, LACM, RBCM	231, 268, 305
Ocenebra tenuisculpta (Carpenter, 1864)	3	CMN	305
Scabrotrophon lasius (Dall, 1919)	14	CMN, LACM, RBCM	297, 298
Scabrotrophon maltzani (Kobelt & Küster, 1878)	3	LACM	
Trophonopsis sp.	4	RBCM	19
Trophonopsis disparilis Dall, 1891	1	LACM	
Family Nassariidae			
Ilyanassa obsoleta (Say, 1822)	1		297
Nassarius sp.	1	RBCM	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Nassarius fossatus (Gould, 1850)	3	RBCM	231
Nassarius mendicus (Gould, 1850)	30	CMN, LACM, RBCM, ROM	98, 297, 298, 305
Nassarius perpinguis (Hinds, 1844)	4	CMN, RBCM	298
Family Neptuneidae			
Beringius sp.	5	CAS, RBCM	
Beringius crebricostatus Dall, 1877	1	RBCM	
Beringius eyerdami Smith, 1959	2	LACM	22
Beringius kennicotti Dall, 1907	1	RBCM	
Colus sp.	5	RBCM, ROM	98
Colus acosmius Dall, 1891	3	LACM	
Colus alphelus Dall, 1890	4	LACM, RBCM	
Colus clementinus (Dall, 1919)	2	LACM	
Colus halibrectus (Dall, 1891)	1	RBCM	
Colus morditus Dall, 1919	1	LACM	
Colus sapius Dall, 1919	1	USNM	45, 133
Colus cf. *severinus* Dall, 1919	1	RBCM	
Mohnia sp.	1	RBCM	
Mohnia freilei Dall, 1891	1	USNM	125, 127, 135, 262
Morisonella pacifica (Dall, 1908)	1	USNM	45
Neptunea sp.	1		9
Neptunea amianta (Dall, 1890)	7	LACM, RBCM	311
Neptunea beringi (Dall, 1902)	1	LACM	
Neptunea humboldtiana Smith, 1971	1	CAS	
Neptunea lyrata Clarke, 1956	7	CMN, LACM, ROM	19, 98
Neptunea middendorffiana (MacGinitie, 1959)	1	LACM	
Neptunea pacifica Dall, 1902	3	LACM, RBCM	
Neptunea phoenicea (Dall, 1891)	1	LACM	
Neptunea pribiloffensis (Dall, 1919)	2	LACM	135
Neptunea smirnia (Dall, 1919)	2	RBCM	297
Neptunea stilesi Smith, 1968	2	CAS	283
Neptunea tabulata (Baird, 1863)	7	CMN, LACM, RBCM	18, 19
Family Nucellidae			
Nucella sp.	17	RBCM	173, 260, 268, 297
Nucella canaliculata (Duclos, 1832)	24	LACM, RBCM	16, 160, 268, 297, 305
Nucella emarginata (Deshayes, 1839)	68	CMN, LACM, RBCM	16, 160, 161, 268, 271, 275, 276, 296, 297, 305
Nucella lamellosa (Gmelin, 1791)	43	CMN, LACM, RBCM	9, 10, 13, 16, 160, 161, 174, 268, 275, 297, 305
Nucella lima (Gmelin, 1791)	6	CMN, RBCM	160, 297
Family Olividae			
Olivella sp.	2		8, 259
Olivella baetica Carpenter, 1864	48	CMN, RBCM, ROM	8, 18, 19, 65, 98, 259, 297, 305
Olivella biplicata (Sowerby, 1825)	8	LACM, RBCM	9, 160, 161, 305
Family Turbinellidae			
Exilioidea rectirostris (Carpenter, 1864)	1	USNM	46

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Volutidae			
Arctomelon stearnsii (Dall, 1872)	5	LACM, RBCM	24
Suborder Toxoglossa			
Family Cancellariidae			
Admete sp.	3	RBCM	
Admete gracilior (Carpenter, 1869)	4	RBCM, ROM	98, 248
Neoadmete circumcincta (Dall, 1873)	1	RBCM	
Neoadmete modesta (Carpenter, 1865)	2		248
Family Turridae			
Aforia crebristriata (Dall, 1908)	1	USNM	45
Aforia goodei (Dall, 1890)	1	LACM	222
Antiplanes sp.	1	RBCM	
Antiplanes perversa (Gabb, 1865)	6	RBCM	18, 19
Kurtzia arteaga (Dall & Bartsch, 1910)	1	CMN	
Kurtziella plumbea (Hinds, 1843)	2	RBCM	
Mangelia sp.	10	RBCM, ROM	98
Mangelia carlottae Dall, 1919	2	USNM	132, 203, 253
Mitromorpha carpenteri Gilbert, 1954	1	CMN	305
Oenopota sp.	8	CMN, RBCM	
Oenopota bicarinata (Couthouy, 1838)	1	CMN	
Oenopota crebricostata (Carpenter, 1864)	5	CMN, RBCM	297
Oenopota decussata (Couthouy, 1838)	1	CMN	
Oenopota excurvata (Carpenter, 1864)	10	ROM	98
Oenopota fidicula (Gould, 1849)	4	CMN	305
Oenopota harpa (Dall, 1885)	2		98, 132
Oenopota krausei (Dall, 1887)	1	USNM	132
Oenopota sculpturata (Dall, 1886)	2	RBCM	124, 305
Oenopota tabulata (Carpenter, 1864)	1	RBCM	
Oenopota trevelliana (Turton, 1834)	1		305
Oenopota turricula (Montagu, 1803)	3	ROM	98
Ophiodermella cancellata (Carpenter, 1864)	2	RBCM	297
Ophiodermella fancherae (Dall, 1903)	4	RBCM	231
Ophiodermella inermis (Hinds, 1847)	5	CMN, RBCM	305
Suavodrillia willetti (Dall, 1919)	1	LACM	222
Taranis strongi (Arnold, 1903)	3	RBCM	297
Subclass Opisthobranchia			
Order Pyramidellacea			
Family Pyramidellidae			
Iselica sp.	1	RBCM	
Iselica obtusa (Capenter, 1864)	1		158
Odostomia sp.	36	RBCM, ROM	9, 98, 297, 298
Odostomia barkleyensis Dall & Bartsch, 1910	2	RBCM	298
Odostomia capitana Dall & Bartsch, 1909	1	RBCM	
Odostomia cassandra Bartsch, 1912	2	CMN, USNM	41, 253
Odostomia cypria Dall & Bartsch, 1912	2	CMN	40, 41, 253
Odostomia inflecta unk	1		128

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Odostomia nuciformis Dall & Bartsch, 1909	1	RBCM	
Odostomia oregonensis Dall & Bartsch, 1907	2	USNM	40, 44, 45, 98, 136, 138, 139, 253
Odostomia pharcida Dall & Bartsch, 1907	1	USNM	40, 138, 139, 253
Odostomia quadrae Dall & Bartsch, 1910	2	RBCM	297
Odostomia skidegatensis Bartsch, 1912	2	CMN, USNM	40, 41, 122
Odostomia tenuisculpta Carpenter, 1864	6	CMN, RBCM, USNM	40, 98, 305, 306
Turbonilla sp.	34	RBCM, ROM	98
Turbonilla aurantia (Carpenter, 1864)	1		98
Turbonilla barkleyensis Bartsch, 1917	1	RBCM	
Turbonilla castanea (Keep, 1887)	1	RBCM	
Turbonilla chocolata (Carpenter, 1866)	1		248
Turbonilla lordi (Smith, 1880)	3	RBCM	40, 138, 139
Turbonilla lyalli Dall & Bartsch, 1907	2	CMN, ROM	98
Turbonilla pesa Dall & Bartsch, 1909	2	RBCM	297
Turbonilla pugetensis Bartsch, 1917	3	ROM	98
Turbonilla stylina (Carpenter, 1864)	2	RBCM	248
Turbonilla taylori Dall & Bartsch, 1907	1	CMN	
Turbonilla torquata (Gould, 1853)	3	RBCM	40, 138, 139, 248
Order Cephalaspidea			
Family Acteonidae			
Rictaxis punctocaelatus (Carpenter, 1864)	4	CMN, RBCM	297
Family Aglajidae			
Aglaja ocelligera (Bergh, 1893)	1	RBCM	
Family Atyidae			
Haminoea sp.	1	RBCM	
?*Haminoea hydatis* (Linnaeus, 1758)	1	CMN	
Haminoea vescicula (Gould, 1855)	1		160
Family Cylichnidae			
Acteocina sp.	2	CMN, RBCM	
Acteocina eximia (Baird, 1863)	24	RBCM	98, 305
Cylichna alba (Brown, 1827)	6	RBCM, ROM	98
Cylichna attonsa (Carpenter, 1865)	26	RBCM, ROM	18, 98, 305
Cylichnella sp.	4	RBCM	297
Cylichnella culcitella (Gould, 1853)	26	CMN, RBCM, ROM	98
Cylichnella harpa *(Dall, 1871)*	8	RBCM	135, 248
Tornatina sp.	1	CMN	
Family Gastropteridae			
Gastropteron sp.	1	ROM	
Gastropteron pacificum Bergh, 1893	3	CMN, RBCM, USNM	137
Family Retusidae			
Volvulella cylindrica (Carpenter, 1864)	3	RBCM	297
Family Scaphandridae			
Scaphandridae	1	RBCM	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Order Anaspidea			
Family Aplysiidae			
?*Aplysia* sp.	1	RBCM	
Order Notaspidea			
Family Pleurobranchidae			
Pleurobranchidae	1	RBCM	
Berthella californica (Dall, 1900)	2		237
Family Tylodinidae			
Anidolyta spongotheras (Bertsch, 1980)	1	CMN	70
?*Tylodina* sp.	1	RBCM	
Order Thecosomata			
Family Peraclididae			
Peracle sp.	6		257
Suborder Euthecosomata			
Family Cavoliniidae			
Clio sp.	3	RBCM	
Clio occidentalis Dall, 1871	1	RBCM	
Diacria trispinosa (de Blainville, 1821)	1	RBCM	
Euclio sp.	9		97
Euclio pyramidata (Linnaeus, 1767)	1		56
Family Limacinidae			
Limacina sp.	19	RBCM	142, 171, 257
Limacina helicina Dall, 1871	53	ROM	97, 98, 142
Suborder Pseudothecosomata			
Family Cymbuliidae			
Cymbuliidae	4		257
Order Gymnosomata			
Suborder Gymnosomina			
Family Clionidae			
Clione sp.	2		257
Clione limacina (Phipps, 1774)	30	RBCM	97, 142
Thliptodon diaphanus (Meisenheimer, 1903)	1		56
Suborder Gymnoptera			
Family Hydromylidae			
Anopsia sp.	1		56
Order Nudibranchia			
Suborder Doridacea			
Family Aldisidae			
Aldisa sanguinea (Cooper, 1863)	1	RBCM	
Aldisa sanguinea cooperi Robilliard & Baba, 1972	1	RBCM	
Family Archidorididae			
Archidoris sp.	3	RBCM	268
Archidoris montereyensis (Cooper, 1863)	15		10, 160, 161, 271, 276, 297

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Archidoris odhneri (MacFarland, 1966)	9	CAS, RBCM	237, 275, 276
Family Chromodorididae			
Cadlina sp.	2	RBCM	268
Cadlina flavomaculata MacFarland, 1905	1		23
Cadlina luteomarginata MacFarland, 1966	8	CAS, RBCM	160, 237, 298
Family Discodorididae			
Anisodoris sp.	1	RBCM	
Anisodoris lentiginosa Millen, 1982	1	RBCM	
Anisodoris nobilis (MacFarland, 1905)	15		8, 16, 160, 237, 275, 276
Discodoris heathi MacFarland, 1905	5	RBCM	237
Discodoris sandiegensis (Cooper, 1862)	15	CAS, RBCM	8, 160, 193, 237, 275, 297
Family Dorididae			
Dorididae sp.	7	CAS, RBCM	
Family Goniodorididae			
Okenia vancouverensis (O'Donoghue, 1921)	3	RBCM	213, 249, 297
Family Onchidorididae			
Acanthodoris sp.	4	CAS, RBCM	
Acanthodoris brunnea MacFarland, 1905	1	RBCM	
Adalaria pacifica Bergh, 1880	2	RBCM	235
Adalaria sp. 1 Undescribed species, Behrens, 1991	1		237
Adalaria sp. 2 n.sp. in prep., S. Millen	1	RBCM	
Adalaria sp. 3 Undescribed species, Millen & Donaldson, 1991	1		237
Diaphorodoris lirulatocauda Millen, 1985	1	RBCM	236
Onchidoris muricata (Müller, 1776)	2		237
Family Polyceridae			
Aegires albopunctatus MacFarland, 1905	2	RBCM	298
Laila cockerelli MacFarland, 1905	4	RBCM	275, 298
Polycera tricolor Robilliard, 1971	3	RBCM	
Triopha sp.	3	CAS	268
Triopha catalinae (Cooper, 1863)	17	RBCM	10, 22, 160, 237, 268, 275, 276, 298
Triopha maculata MacFarland, 1905	1	CAS	
Family Rostangidae			
Rostanga pulchra MacFarland, 1905	9	CAS	160, 237, 268
Suborder Dendronotacea			
Family Dendronotidae			
Dendronotus sp.	1	RBCM	
Dendronotus albus MacFarland, 1966	1	RBCM	
Dendronotus diversicolor Robilliard, 1970	2		237
Dendronotus frondosus (Ascanius, 1774)	1	RBCM	
Dendronotus iris Cooper, 1863	1	RBCM	
Family Dotoidae			
Doto columbiana O'Donoghue, 1921	2	RBCM	235
Family Fimbriidae			
Melibe leonina (Gould, 1853)	7	RBCM	193, 250, 268

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Tritoniidae			
Tochuina tetraquetra (Pallas, 1788)	4		237, 250, 259
Tritonia sp.	1	RBCM	
Tritonia diomedea Bergh, 1894	1		275
Tritonia festiva (Stearns, 1873)	4	CAS, RBCM	237
Suborder Arminacea			
Family Arminidae			
Armina sp.	2		259
Armina californica (Cooper, 1863)	8	CMN, RBCM	237, 249
Family Dironidae			
Dirona albolineata MacFarland in Cockerell & Elliot 1905	10	RBCM	268, 275, 298
Family Zephyrinidae			
Antiopella sp.	3	RBCM	
Antiopella barbarensis (Cooper, 1863)	2	CAS	237
Suborder Aeolidacea			
Family Aeolidiidae			
Aeolidea papillosa (Linnaeus, 1761)	11	CAS, RBCM	10, 297, 298
Family Eubranchidae			
Eubranchus sp.	1	RBCM	
Eubranchus rustyus Marcus, 1961	1		237
Family Facelinidae			
Hermissenda crassicornis (Eschscholtz, 1831)	28	CAS, RBCM	9, 10, 160, 161, 237, 275, 276, 297, 298
Family Fionidae			
Fiona pinnata (Eschscholtz, 1831)	1	RBCM	
Family Flabellinidae			
Flabellina sp.	1	RBCM	
Flabellina pricei (MacFarland, 1966)	1		237
Flabellina trilineata (O'Donoghue, 1921)	2		237
Flabellina verrucosa (Sars, 1829)	1		237
Order Stylommatophora			
Suborder Sigmurethra			
Infraorder Aulacopoda			
Family Arionidae			
Ariolimax sp.	1	RBCM	
Ariolimax columbianus (Gould, 1851)	1	RBCM	
Prophysaon sp.	4	CAS	
Infraorder Holopoda			
Family Polygyridae			
Polygyra sp.	1	RBCM	
Vespericola sp.	4	CAS, RBCM	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Infraorder Holopodopes			
Family Haplotrematidae			
Haplotrema vancouverense (Lea, 1839)	6	CAS, RBCM	
Subclass Gymnomorpha			
Order Onchidiacea			
Family Onchidiidae			
Onchidella sp.	2	RBCM	297
Onchidella borealis Dall, 1871	27	CAS, FMNH, RBCM	10, 160, 268, 297, 298
Subclass Pulmonata			
Order Basommatophora			
Family Siphonariidae			
Siphonaria sp.	1	RBCM	
Siphonaria thersites Carpenter, 1864	6	CMN, RBCM	160, 305
? *Williamia peltoides* (Carpenter, 1864)	1		21
Class Bivalvia			
Subclass Protobranchia			
Order Solemyoida			
Superfamily Solemyoidea			
Family Solemyidae			
Acharax johnsoni Dall, 1891	1	RBCM	
Solemya reidi Bernard, 1980	2	RBCM	
Order Nuculoida			
Superfamily Nuculoidea			
Family Nuculidae			
Acila castrensis (Hinds, 1843)	48	CMN, RBCM, ROM	8, 9, 18, 19, 98, 297, 305
Eunucula tenuis (Montagu, 1908)	36	CMN, RBCM, ROM	98, 160, 305
Nucula sp.	2		260
Nucula carlottensis Dall, 1897	1	RBCM	128, 203, 253
Nucula linki Dall, 1916	1		135
Superfamily Nuculanoidea			
Family Malletiidae			
Katadesmia gibbsi (Dall, 1897)	1		128, 203, 253
Malletia sp.	1	RBCM	
Malletia faba Dall, 1897	1	USNM	128, 253
Family Neilonellidae			
Austrotindaria gibbsii (Dall, 1897)	1	USNM	
Family Nuculanidae			
Subfamily Nuculaninae			
Nuculana sp.	8	CMN, RBCM, ROM	98
Nuculana acuta Link, 1807	15	RBCM	231, 248, 305
Nuculana cellulita (Dall, 1896)	1	RBCM	
Nuculana conceptionis (Dall, 1896)	1	RBCM	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Nuculana extenulata (Dall, 1897)	3	ROM, USNM	45, 98, 128
Nuculana fossa (Baird, 1863)	13	RBCM, ROM	98, 248
Nuculana hamata (Carpenter, 1864)	6	RBCM, ROM	8, 98
Nuculana minuta (Müller, 1776)	17	CMN, RBCM, ROM	18, 98, 297, 298
Nuculana navissa (Dall, 1916)	1		231
Nuculana penderi (Dall & Bartsch, 1910)	1	CMN	
Nuculana pernula (Müller, 1779)	5	ROM	98
Nuculana taphria (Dall, 1896)	5	RBCM, ROM	98, 297
Family Tindariidae			
Tindaria kennerlyi (Dall, 1897)	2	LACM, USNM	135
Family Yoldiidae			
Subfamily Yoldiellinae			
Yoldiella orcia (Dall, 1916)	1	RBCM	
Subfamily Yoldiinae			
Megayoldia martyria (Dall, 1897)	1		98
Megayoldia montereyensis (Dall, 1893)	1		7
Megayoldia thraciaeformis (Storer, 1838)	5	RBCM	95, 98, 160
Yoldia sp.	5	CMN, RBCM, ROM	98
Yoldia hyperborea Torrell, 1859	13	RBCM, ROM	98
Yoldia myalis (Couthouy, 1838)	7	ROM	98
Yoldia seminuda Dall, 1871	26	CMN, RBCM, ROM	18, 19, 95, 98, 160, 305
Subclass Pteriomorphia			
Order Arcoida			
Superfamily Glycymeridoidea			
Family Glycymerididae			
Glycymeris sp.	3	RBCM	259
Glycymeris corteziana Dall, 1916	3	RBCM	298
Glycymeris septentrionalis (Middendorff, 1849)	4	CMN, RBCM	305
Glycymeris subobsoleta (Carpenter, 1864)	35	RBCM, ROM	65, 98, 298
Superfamily Limopsoidea			
Family Limopsidae			
Limopsis akutanica Dall, 1916	1	RBCM	
Superfamily Philobryoidea			
Family Philobryidae			
Philobrya setosa (Carpenter, 1864)	3	CMN, RBCM	305
Order Mytiloida			
Superfamily Mytiloidea			
Family Mytilidae			
Mytilidae	2	RBCM	
Subfamily Crenellinae			
Crenella decussata (Montagu, 1808)	15	CMN, RBCM, ROM	98, 305
Musculus sp.	2		10, 65
Musculus discors (Linnaeus, 1767)	2	RBCM, CMN	
Musculus niger (Gray, 1824)	6	CMN, RBCM, ROM	98
Musculus taylori (Dall, 1897)	2	RBCM	231
Solamen columbiana Dall, 1897	12	RBCM, ROM	98

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Vilasina seminuda (Dall, 1897)	1	RBCM	
Vilasina vernicosa (Middendorf, 1849)	1		128
Subfamily Dacriniinae			
Dacrydium pacificum Dall, 1916	1	RBCM	
Dacrydium vitreum (Moller, 1842)	15	ROM	98
Subfamily Lithophaginae			
Adula californiensis (Philippi, 1847)	3	RBCM	231
Subfamily Modiolinae			
Modiolus sp.	5	RBCM	174, 260
Modiolus modiolus (Linnaeus, 1758)	13	RBCM	297
Modiolus rectus (Conrad, 1837)	13	CMN, LACM, RBCM	10, 160, 276
Subfamily Mytilinae			
Mytilus sp.	2	RBCM	
Mytilus californianus Conrad, 1837	98	CMN, RBCM	1, 8, 9, 10, 11, 12, 16, 21, 160. 161, 268, 275, 276, 297, 298, 305
Mytilus trossulus Gould, 1850	88	CMN, RBCM	10, 11, 16, 65, 160, 161, 174, 268, 271, 296, 297, 298
Order Limoida			
Superfamily Limoidea			
Family Limidae			
Limatula attenuata Dall, 1916	1	RBCM	
Order Ostreoida			
Suborder Ostreina			
Superfamily Ostreoidea			
Family Ostreidae			
Subfamily Crassostreinae			
**Crassostrea gigas* (Thunberg, 1793)	1	CMN	
Suborder Pectinina			
Superfamily Pectinoidea			
Family Pectinidae			
Crassadoma sp.	9	RBCM	259, 268
Crassadoma gigantea (Gale, 1928)	5	CMN, RBCM	268
Subfamily Camptonectinae			
Delectopecten sp.	5	RBCM	
Delectopecten vancouverensis (Whiteaves, 1893)	15	MCZ, RBCM, ROM	23, 98
Subfamily Chlamydinae			
Tribe Chlamydini			
Chlamys sp.	61	RBCM	9, 22, 259, 260, 268
Chlamys hastata (Sowerby, 1842)	33	CMN, RBCM, USNM	275, 276, 297, 298, 305
Chlamys rubida (Hinds, 1845)	28	CMN, RBCM, ROM	18, 19, 65, 98, 260
Tribe Crassadomini			
Crassadoma gigantea (Gray, 1825)	80	CMN, RBCM	1, 8, 9, 10, 11, 12, 13, 14, 16, 20, 160, 238, 271, 275, 276, 297, 298, 305

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Tribe Fortipectinini			
Patinopecten caurinus (Gould, 1850)	8	CMN, RBCM	9, 260, 268
Family Propeamussidae			
Cyclopecten sp.	2	CAS, RBCM	
Cyclopecten argentus Bernard, 1978	1		64
Cyclopecten carlottensis Bernard, 1968	5	CAS, CMN, RBCM, USNM	59
Cyclopecten greenlandicus (Sowerby, 1842)	1	LACM	116
Parvamussium alaskense Dall, 1871	9	LACM, RBCM, ROM, USNM	18, 98, 253, 298
Propeamussium sp.	4	RBCM	
Superfamily Anomioidea			
Family Anomiidae			
Anomia sp.	1		259
Pododesmus sp.	52	RBCM	173, 259, 260
Pododesmus macroschisma (Deshayes, 1839)	41	CMN, RBCM	1, 10, 13, 160, 161, 276, 297, 298, 305
Subclass Heterodonta			
Order Veneroida			
Superfamily Lucinoidea			
Family Lucinidae			
Lucinidae	6	ROM	98
Lucina sp.	1	RBCM	
Parvilucina tenuisculpta Carpenter, 1864	35	CMN, RBCM, ROM	98, 160, 297, 305
Subfamily Myrteinae			
Lucinoma annulatum Reeve, 1850	31	CMN, RBCM, ROM	18, 19, 98, 174, 305
Family Thyasiridae			
Subfamily Axinopsidinae			
Adontorhina cyclia Berry, 1947	1		98
Axinopsida serricata (Carpenter, 1864)	69	CMN, RBCM, ROM	23, 65, 66, 98, 160, 291, 298, 305
Mendicula sp.	2	RBCM	
Mendicula ferruginosa (Forbes, 1844)	1	RBCM	
Subfamily Thyasirinae			
Conchocele bisecta (Conrad, 1849)	1	LACM	
Thyasira sp.	2	RBCM	
Thyasira flexuosa (Montagu, 1803)	16	CMN, ROM	23, 98, 129, 305
Family Ungulinidae			
Diplodonta orbella (Gould, 1851)	6	CMN, RBCM	298, 305
Superfamily Astartoidea			
Family Astartidae			
Subfamily Astartinae			
Astarte sp.	5	RBCM, ROM	8, 98
Astarte alaskensis Dall, 1903	27	CMN, RBCM, ROM	18, 19, 23, 98, 260, 297, 298
Astarte borealis (Schumacher, 1817)	2	ROM	98
Astarte compacta Carpenter, 1864	2	RBCM	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Astarte crenata (Gray, 1824)	1	LACM	
Astarte elliptica (Brown, 1827)	1	LACM	
Astarte esquimalti (Baird, 1863)	33	CMN, LACM, RBCM, ROM	18, 98, 298
Astarte montagui (Dillwyn, 1817)	3	ROM	98
Superfamily Carditoidea			
Family Carditidae			
Subfamily Carditamerinae			
Cyclocardia sp.	1	RBCM	
Cyclocardia crassidens (Broderip & Sowerby, 1829)	4	CAS, RBCM	114, 298
Cyclocardia crebricostata (Krause, 1885)	7	RBCM	248, 297, 305
Cyclocardia ventricosa (Gould, 1850)	42	CMN, RBCM, ROM	98, 174
Glans carpenteri (Lamy, 1922)	9	LACM, RBCM	114, 135, 160, 248, 253
Miodontiscus prolongatus (Carpenter, 1864)	10	CMN, RBCM	298, 305
Superfamily Chamoidea			
Family Chamidae			
?*Chama arcana* Bernard, 1976	1		298
?*Pseudochama granti* Strong, 1934	1		298
Superfamily Galeommatoidea			
Family Lasaeidae			
Lasaeidae	1	RBCM	
Kellia suborbicularis (Montagu, 1803)	8	CMN, RBCM	160, 305
Lasaea sp.	1	CAS	
Lasaea adansoni (Gmelin, 1791)	2	RBCM	10, 298
?*Mysella compressa* Angas, 1877	1		98
Mysella planata (Krause, 1885)	1	LACM	
Neaeromya rugifera (Carpenter, 1864)	2	CMN, ROM	98, 305
Rhamphidonta retifera (Dall, 1899)	1		25
Rochefortia tumida (Carpenter, 1864)	39	CMN, RBCM, ROM	98, 291, 298, 305
Superfamily Arcticoidea			
Family Kelliellidae			
Kelliella galatheae Knudsen, 1970	1	RBCM	67
Superfamily Glossoidea			
Family Vesicomyidae			
Vesicomya kilmeri (Bernard, 1974)	3	CAS	63
Superfamily Cardioidea			
Family Cardiidae			
Subfamily Clinocardiinae			
Clinocardium sp.	127	CMN	19, 174, 259, 260, 268
Clinocardium blandum (Gould, 1850)	30	RBCM, ROM	98, 298, 305
Clinocardium californiense (Deshayes, 1839)	4	CMN	65
Clinocardium ciliatum (Fabricius, 1780)	11	RBCM, ROM	98
Clinocardium nuttallii (Conrad, 1837)	54	CMN, RBCM, ROM	10, 16, 18, 65, 66, 98, 160, 259, 275, 276, 296, 297, 305
Serripes sp.	1		259
Serripes groenlandicus *(Mohr, 1786)*	4	RBCM	297

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Serripes laperousii (Deshayes, 1839)	1	CMN	
Subfamily Laevicardiinae			
Nemocardium centrifilosum (Carpenter, 1864)	47	CMN, RBCM, ROM	18, 19, 65, 66, 98, 135
Superfamily Veneroidea			
Family Petricolidae			
Cooperella subdiaphana (Carpenter, 1864)	3	RBCM	135, 253
Family Turtoniidae			
Turtonia minuta (Fabricius, 1780)	1	RBCM	
Family Veneridae			
Veneridae	2	RBCM	
Subfamily Clementiinae			
Compsomyax sp.	12		259, 260
Compsomyax subdiaphana (Carpenter, 1864)	34	CMN, RBCM, ROM	18, 98, 174, 298, 305
Subfamily Pitarinae			
Nutricola lordi (Baird, 1863)	50	CMN, RBCM, ROM	65, 66, 98, 291, 305
Nutricola ovalis (Dall, 1902)	3	RBCM	
Nutricola tantilla (Gould, 1853)	11	RBCM, ROM	65, 98, 298
Saxidomus sp.	165		259, 260
Saxidomus gigantea (Deshayes, 1839)	49	CMN, RBCM	8, 9, 11, 160, 174, 259, 268, 275, 296, 297, 298
Saxidomus nuttali Conrad, 1837	2		10, 305
Subfamily Tapetinae			
Liocyma sp.	1	RBCM	
**Venerupis philippinarum* (Adams & Reeve, 1850)	3	RBCM	297, 298
Subfamily Venerinae			
Humilaria sp.	10		259, 260
Humilaria kennerleyi (Reeve, 1863)	21	CMN, RBCM	1, 8, 10, 298, 305
Protothaca sp.	26		174, 259, 260, 268
Protothaca staminea (Conrad, 1837)	36	CMN, RBCM	8, 10, 11, 13, 16, 98, 160, 297, 298, 305
Protothaca tenerrima (Carpenter, 1857)	3	RBCM	9, 297, 298
Superfamily Tellinoidea			
Family Psammobiidae			
Gari californica (Conrad, 1849)	13	CAS, CMN, RBCM	9, 98, 260, 305
Family Semelidae			
Semele rubropicta Dall, 1871	22	CMN, RBCM	11, 13, 297, 298
Family Tellinidae			
Tellinidae	1	RBCM	
Subfamily Macominae			
Macoma sp.	15	RBCM, ROM	98, 160, 174, 260, 268, 296
Macoma balthica (Linnaeus, 1758)	8	CMN	174, 268, 305
Macoma brota Dall, 1916	2	CMN, RBCM	
Macoma calcarea (Gmelin, 1791)	8	CMN, RBCM	9, 18, 160, 281, 305
Macoma carlottensis Whiteaves, 1880	12	CMN, RBCM	65, 66, 98, 113, 248, 305
Macoma eliminata Dunnill & Coan, 1968	25	RBCM, ROM	65, 98, 160
Macoma expansa Carpenter, 1864	1		128

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Macoma inquinata (Deshayes, 1855)	7	CMN, RBCM	174, 298, 305
Macoma lama Bartsch, 1929	3	CAS, RBCM, SU	113
Macoma lipara Dall, 1916	11	ROM	98, 160
Macoma moesta (Deshayes, 1855)	3	ROM	65, 98
Macoma nasuta (Conrad, 1837)	10	CMN, RBCM	8, 144, 160, 174, 268
Macoma secta (Conrad, 1837)	2	LACM	174
Macoma yoldiformis Carpenter, 1864	9	CMN, RBCM, ROM	98, 144, 248
Subfamily Tellininae			
Tellina sp.	3	RBCM	260
Tellina bodegensis Dall, 1900	6	RBCM	65, 113, 135, 231, 253
Tellina carpenteri Dall, 1900	32	RBCM, ROM	18, 65, 66, 98
Tellina meropsis Dall, 1900	1	CMN	
Tellina modesta Verrill, 1872	9	RBCM, ROM	98
Tellina nuculoides (Reeve, 1854)	54	CMN, RBCM, ROM	18, 65, 98, 160
Tellina salmonea (Carpenter, 1864)	2	CMN, RBCM	
Superfamily Solenoidea			
Family Pharidae			
Siliqua sp.	14		259, 260
Siliqua patula (Dixon, 1789)	39	CMN, RBCM	65, 226, 253, 259, 260, 305
Family Solenidae			
Solen sp.	2		259
Solen sicarius Gould, 1850	8	CAS, CMN, RBCM	259
Superfamily Mactroidea			
Family Mactridae			
Mactridae	91	RBCM	259, 260
Subfamily Lutariinae			
Tresus sp.	125		259, 260, 268
Tresus capax (Gould, 1850)	25	CMN, RBCM	8, 9, 10, 11, 16, 160, 174, 275
Subfamily Mactrinae			
Mactromeris polynyma (Stimpson, 1860)	4	RBCM	
Simomactra falcata (Gould, 1850)	30	CMN, RBCM, ROM	18, 98, 160, 248, 305
Order Myoida			
Suborder Myina			
Superfamily Myoidea			
Family Myidae			
Myidae	2	RBCM	
Subfamily Cryptomyinae			
Cryptomya sp.	1	RBCM	
Cryptomya californica (Conrad, 1837)	1		305
Subfamily Myinae			
Mya sp.	2	CMN	268
**Mya arenaria* Linnaeus, 1758	19	CMN, RBCM	160, 174, 261, 268, 297
Mya truncata Linnaeus, 1758	16	CAS, CMN, RBCM	65, 174, 259, 260, 305
Platyodon cancellatus (Conrad, 1837)	5	LACM, RBCM	297

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Superfamily Hiatelloidea			
Family Hiatellidae			
Subfamily Hiatellinae			
Hiatella sp.	4	CMN, RBCM	
Hiatella arctica (Linnaeus, 1767)	70	CAS, CMN, RBCM, ROM	10, 23, 65, 98, 160, 174, 297, 298, 305
Panomya ampla Dall, 1898	4	RBCM	
Panomya artica (Lamarck, 1818)	1	RBCM	
Panopea sp.	36		259, 260
Panopea abrupta (Conrad, 1849)	20		1, 9, 160, 259, 260, 268, 275, 298
Suborder Pholadina			
Superfamily Pholadoidea			
Family Pholadidae			
Subfamily Jouannetiinae			
Netastoma japonicum (Yokoyama, 1920)	4	LACM, RBCM	302
Subfamily Martesiinae			
Chaceia ovoidea (Gould, 1851)	1	CMN	
Penitella richardsoni Kennedy, 1989	2		198, 302
Penitella penita (Conrad, 1837)	3	RBCM, USNM	301
Subfamily Pholadinae			
Zirfaea pilsbryi Lowe, 1931	5	CMN, RBCM, USNM	300, 305
Family Teredinidae			
Teredinidae	2	RBCM	
Subfamily Bankiinae			
Bankia setacea (Tryon, 1863)	1	RBCM	72
Subclass Anomalodesmata			
Order Pholadomyoida			
Superfamily Pandoroidea			
Family Pandoridae			
Pandora sp.	3	RBCM, ROM	98
Pandora bilirata Conrad, 1855	30	RBCM, ROM	18, 19, 98
Pandora filosa (Carpenter, 1864)	16	CMN, RBCM, ROM	98, 305
Pandora glacialis Leach, 1819	4	RBCM	
Pandora wardiana (Adams, 1860)	4	CMN, RBCM	
Family Lyonsiidae			
Agriodesma sp.	1	RBCM	
Entodesma navicula (Adams & Reeve, 1860)	4	CMN	8, 10, 305
Lyonsia sp.	3	RBCM	259
Lyonsia bracteata (Gould, 1850)	4	ROM	98
Lyonsia californica Conrad, 1837	26	CMN, RBCM, ROM	65, 98, 305
Mytilimeria nuttalli Conrad, 1837	4	CMN	160, 305

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Superfamily Thracioidea			
Family Thraciidae			
Thracia challisiana Dall, 1915	2	LACM	
Thracia curta Conrad, 1837	2	CMN	305
Thracia devexa Sars, 1878	2	LACM	115
Order Septibranchia			
Superfamily Cuspidarioidea			
Family Cuspidariidae			
Cuspidariidae	1	RBCM	
Bathyneaera tillamookensis (Dall, 1916)	2	CMN	62
Cardiomya sp.	6	RBCM, ROM	95, 98
Cardiomya pectinata (Carpenter, 1864)	27	CMN, RBCM, ROM	62, 98, 305
Cardiomya planetica (Dall, 1908)	10	CMN, RBCM, ROM	18, 62, 98
Cuspidaria apodema Dall, 1916	5	USNM	62, 131
Cuspidaria cowani Bernard, 1967	2	CMN	58, 62
Superfamily Verticordioidea			
Family Verticordiidae			
Subfamily Lyonsiellinae			
Dallicordia alaskana (Dall, 1895)	5	USNM	62, 127
Lyonsiella quaylei Bernard, 1969	2	CMN	62
Subfamily Verticordiinae			
Halicarida perplicata (Dall, 1890)	3	RBCM	7, 24
Superfamily Poromyoidea			
Family Poromyidae			
Cetomya malespinae (Dall, 1916)	2	USNM	45, 62, 188
Dermatomya tenuiconcha (Dall, 1913)	3		62
Class Cephalopoda			
Subclass Coleoidea			
Order Sepioidea			
Family Sepiolidae			
Rossia sp.	1	RBCM	
Rossia pacifica Berry, 1912	9	CMN, RBCM	18, 19, 65
Order Teuthoidea			
Suborder Myopsida			
Family Loliginidae			
Loligo sp.	1	RBCM	
Loligo opalescens Berry, 1911	4	CMN	10, 297
Suborder Oegopsida			
Family Chiroteuthidae			
Chiroteuthidae	2	RBCM	
Chiroteuthis calyx Voss, 1967	4		191
Family Cranchiidae			
Taonis pavo (LeSueur, 1821)	2		191
Galiteuthis phyllura Berry, 1911	1		191

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Enoploteuthidae			
Abraliopsis felis McGowan & Okutani, 1968	1		191, 311
Family Gonatidae			
Berryteuthis anonychus (Pearcy & Voss, 1963)	3	RBCM	191
Berryteuthis magister (Berry, 1913)	9	CMN	191, 311
Gonatopsis sp.	1	CMN	
Gonatopsis borealis Sasaki, 1923	2		191
Gonatus sp.	3	CMN	
Gonatus berryi Naef, 1923	1	RBCM	
Gonatus madokai Kubodera & Okutani, 1977	1		191
Gonatus onyx Young, 1972	7	RBCM	191
Gonatus pyros Young, 1972	7		191
Gonatus type C Kubodera, 1978	3		191
Gonatus ursabrunae Jefferts, 1985	1	OSU	192
Family Onychoteuthidae			
?*Moroteuthis robusta* Verrill, 1876	1		176
Order Octopoda			
Suborder Cirrata			
Family Opisthoteuthidae			
Opisthoteuthis californiana Berry, 1949	4	RBCM	311
Suborder Incirrata			
Family Bolitaenidae			
Japatella sp.	1	RBCM	
Japatella diaphana Hoyle, 1885	3	RBCM	191
Family Octopodidae			
Octopodidae	2	RBCM	17
Benthoctopus sp.	2		303, 311
Benthoctopus leioderma (Berry, 1911)	3		311
Benthoctopus robustus Voss & Pearcy, 1990	2	USNM	304, 311
Enteroctopus dofleini dofleini (Wülker, 1910)	17	CMN, RBCM	9, 160, 193, 271, 275, 276, 298
Octopus sp.	27	RBCM	9, 22, 23, 24, 97, 171, 259, 271
Octopus sp. A of Jefferts, 1983			
Octopus rubescens Berry, 1953	2	RBCM	
Class Scaphopoda			
Order Dentalida			
Family Dentaliidae			
Dentaliidae	5	RBCM	24, 259
Dentalium sp.	1		95
Dentalium pretiosum Sowerby, 1860	19	CMN, MCZ, RBCM, ROM	8, 98, 248, 305
Family Laevidentaliidae			
Dentalium rectius (Carpenter, 1865)	35	RBCM, ROM	18, 19, 98, 160

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Order Gadilida			
Family Gadilidae			
Cadulus sp.	6	RBCM	23, 24, 98
Cadulus aberrans Whiteaves, 1887	1	CAS	
Cadulus californicus (Pilsbry & Sharp, 1898)	4	ROM	98
Cadulus hepburni (Dall, 1897)	1		98
Family Pulsellidae			
Pulsellum salishorum Marshall, 1980	29	ROM	98
Phylum Arthropoda (Crustaceans, Insects, Arachnids)			
Subphylum Chelicerata			
Class Pycnogonida			
Order Pantopoda			
Family Ammotheidae			
Achelia alaskensis Cole, 1904	2	ROM	98, 274
Family Nymphonidae			
Heteronymphon bioculatum Turpaeva, 1956	1		7
Family Pallenidae			
Pseudopallene sp.	1	RBCM	
Pseudopallene circularis (Goodsir, 1842)	1	RBCM	
Order Pegmata			
Suborder Eupantopodida			
Superfamily Iuventivellenoidea			
Family Colossendidae			
Hedgpethia californica (Hedgpeth, 1939)	1		7
Class Arachnida			
Order Pseudoscorpionida			
?Pseudoscorpionida	2		268
Subclass Acarina			
Order Acarina			
Family Bdellidae			
Neomolgus littoralis (Linnaeus, 1758)	4		160, 161
Order Parasitiformes			
Suborder Mesostigmata			
Superfamily Gamasida			
Family Halarachinidae			
Halarachne sp.	1		218
Halarachne halichoeri Allman, 1847	1		218
Halarachne miroungae Ferris, 1925	1		218
Orthohalarachne attenuata (Banks, 1910)	1		218
Orthohalarachne diminuata (Doetschman, 1944)	1		218

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Orthohalarachne zalophi (Oudemans, 1916)	1		218
Subphylum Unirama			
Class Insecta			
Subclass Pterygota			
Order Anoplura			
Family Echinophthiridae			
Antarctophthirus callorhini (Osborn, 1899)	1		218
Antarctophthirus microchir (Troussart & Neumann, 1888)	1		218
Echinophthirius horridus (Olfers, 1816)	1		218
Proechinophthirus fluctus (Ferris, 1916)	1		218
Order Coleoptera			
Family Cantharidae			
Cyrtomoptera divisus (Leconte, 1851)	1		197
Family Carabidae			
Tribe Bembidiini			
Bembidion indistinctum Dejean, 1831	1		197
Bembidion sejunctum semiaurium Fall, 1922	1		195
Bembidion zephyrum Fall, 1910	1		195
Tribe Cychrini			
Scaphinotus marginatus Fischer von Waldheim, 1820	1		195
Tribe Harpalini			
Bradycellus nigrinus Dejean, 1829	1		195
Harpalus sommulentus Dejean, 1829	1		195
Trichocellus cognatus Gyllenhal, 1827	1		195
Tribe Nebriini			
Nebria charlottae Lindroth, 1961	1		195
Nebria diversa LeConte, 1863	1		195
Nebria louisae Kavanaugh, 1984	1	CAS	194, 195
Nebria mannerheimii Fischer von Waldheim, 1828	1		195
Tribe Pterostichini			
Pterostichus adstrictus Eschscholtz, 1823	1		195
Pterostichus algidus LeConte, 1852	1		195
Pterostichus crenicollis LeConte, 1873	1		195
Pterostichus luczotii Dejean, 1828	1		197
Tribe Scaritini			
Dyschirius pacificus Lindroth, 1961	1		195
Dyschirius tridentatus LeConte, 1852	1		197
Tribe Trechini			
Trechus chalybeus Dejean, 1831	1		195
**Trechus obtusus* Erichson, 1837	4		196
Trechus ovipennis Motschulsky, 1845	1		197
Tribe Zabrini			
Amara ellipsis Casey, 1918	1		195
Amara littoralis Mannerheim, 1843	1		195
Family Elateridae			
Hypolithus musculus (Eschscholtz, 1822)	1		197

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Heteroceridae			
Lapsus tristis (Mannerheim, 1853)	1		197
Family Hydrophilidae			
Cercyon fimbriatum Mannerheim, 1852	1		197
Family Lucanidae			
Platyceropsis keeni Casey, 1895	1		197
Family Oedemeridae			
Ditylus quadricollis Leconte, 1851	1		197
Family Scarabaeidae			
Aegialia crassa Leconte, 1857	1		197
Aegialia cylindrica (Eschscholtz, 1822)	1		197
Trichiorhyssemus riparius Horn, 1871	1		197
Family Tenebrionidae			
Phaleria globosa Leconte, 1852	1		197
Suborder Polyphaga			
Superfamily Curculionoidea			
Family Curculionidae			
Lepidophorus inquinatus (Mannerheim, 1852)	1		197
Neophycocoetes testaceus (Leconte, 1876)	10		2, 197
Rhyncolus sp.	1		197
Subfamily Cossoninae			
Tribe Rhyncolini			
Elassoptes marinus Horn, 1873	6		2, 197
Subfamily Molytinae			
Tribe Emphyastini			
Emphyastes fucicola Mannerheim, 1852	3		2, 197
Tribe Plinthini			
Sthereus ptinoides (Germar, 1824)	3		2, 197
Superfamily Staphylinoidea			
Family Staphylinidae			
Adota maritima (Mannerheim, 1843)	1		197
Aleochara littoralis Maklin, 1853	1		197
Aleochara sulcicollis Mannerheim, 1843	1		197
Anthobium keeni Fauvel	1		197
Atheta granulata (Mannerheim, 1846)	1		197
Bledius albonotatus Maklin, 1853	1		197
Bryobiota keeni Fauvel	1		197
Cafius canescens (Malkin, 1852)	3	ERIC, MCZ	197, 254
Cafius femoralis (Malkin, 1852)	3	ERIC, MCZ	197, 254
Cafius luteipennis Horn, 1884	3	ERIC, MCZ	197, 254
Cafius seminitens Horn, 1884	3	ERIC, MCZ	197, 254
Diaulota insolita Casey, 1893	1		197
Hadrotes crassus Mannerheim, 1846	1		197
Heterothops asperatus Smetana, 1971	1		197
Liparocephalus brevipennis Maklin, 1853	1		197
Omalium algarum (Casey, 1885)	1		197
Philhygra comparabilis (Maklin, 1853)	1		197

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Tarphiota fucicola (Maklin, 1852)	1		197
Tarphiota geniculata (Maklin, 1852)	1		197
Thinobius pygmaeus Casey, 1889	1		197
Order Diptera			
Family Asilidae			
Lasiopogon actius Melander, 1923	1		15
Suborder Nematocera			
Infraorder Culicomorpha			
Family Chironomidae			
Saunderia clavicornis (Saunders, 1928)	11		245
Saunderia marinus (Saunders, 1928)	4		245
Saunderia pacificus (Saunders, 1928)	2		245
Subfamily Telmatogetoninae			
Paraclunio alaskensis (Coquillett, 1900)	8		245
Subphylum Crustacea			
Class Branchiopoda			
Subclass Diplostraca			
Order Cladocera			
Suborder Eucladocera			
Family Bosminidae			
Bosmina sp.	1		65
Family Podonidae			
Evadne sp.	20		142, 257
Podon sp.	17		142, 257
Pseudevadne tergestina (Claus, 1877)	3		291
Class Copepoda			
Order Calanoida			
Suborder Amphascandria			
Family Aetideidae			
Aetideus bradyi Scott, 1909	1	USNM	309
Aetideus divergens Bradford, 1971	11	USNM	106, 142, 309
Aetideus pacificus Brodsky, 1950	1		142
?*Bradyidius similis* Sars, 1902	2		106
Chiridius sp.	4		106
?*Chiridius gracilis* Farran, 1908	1		106
Euchirella bitumida With, 1915	1	USNM	309
Euchirella galeata Giesbrecht, 1888	1	USNM	309
Gaetanus sp.	2		106
Gaetanus intermedius Campbell, 1930	2	CMN	256
Gaidius affinis Sars, 1905	1	USNM	309
Gaidius brevispinus (Sars, 1900)	5	CMN, USNM	309
Pseudeuchaeta brevicauda Sars, 1905	2	USNM	309
Pseudochirella polyspina Brodsky, 1950	1	CMN	
Family Calanidae			
Calanus sp.	2	RBCM	142
Calanus helgolandicus (Claus, 1863)	1	USNM	309

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Calanus marshallae Frost, 1974	15		142, 257
Calanus pacificus Brodsky, 1948	63	USNM	4, 106, 142, 171, 309
Mesocalanus tenuicornis (Dana, 1849)	21		157
Neocalanus sp.	1		99
Neocalanus cristatus (Kröyer, 1848)	45	CMN, USNM	106, 142, 156, 157, 171, 309
Neocalanus gracilis (Dana, 1849)	1	USNM	309
Neocalanus plumchrus (Marukawa, 1921)	28	USNM	106, 142, 156, 171, 257, 309
Neocalanus robustior (Giesbrecht, 1888)	1	USNM	309
Family Clausocalanidae			
Clausocalanus arcuicornis (Dana, 1849)	1		106
Clausocalanus lividus Frost & Fleminger, 1968	2		171
Ctenocalanus vanus Giesbrecht, 1888	2		171
Microcalanus pygmaeus Sars, 1900	1		142
Pseudocalanus sp.	2		171
Pseudocalanus minutus (Kröyer, 1845)	117	USNM	106, 142, 229, 257, 291, 309
Family Eucalanidae			
Eucalanus attenuatus (Dana, 1853)	3	USNM	309
Eucalanus bungii bungii Giesbrecht, 1892	28		106, 142, 156, 257
Eucalanus californicus Johnson, 1938	2	USNM	309
Eucalanus monachus Giesbrecht, 1888	2	USNM	309
?*Rhincalanus nasutus* Giesbrecht, 1888	1		106
Family Euchaetidae			
Euchaeta sp.	2	RBCM	
Euchaeta elongata Esterly, 1913	6	RBCM	106, 142
Euchaeta erebi (Farran, 1929)	2	USNM	309
Euchaeta gracilis (Sars, 1905)	3	USNM	309
Euchaeta hanseni (With, 1915)	1	USNM	
Euchaeta norvegica (Boeck, 1872)	2	USNM	309
Euchaeta sarsi (Farran, 1908)	1	USNM	309
Euchaeta spinosa Giesbrecht, 1892	3	USNM	309
Euchaeta tonsa Giesbrecht, 1895	1	USNM	309
Family Megacalanidae			
Bathycalanus bradyi (Wolfenden, 1905)	1		15
Megacalanus princeps (Brady, 1883)	3	USNM	309
Family Metridiidae			
Gaussia princeps (Scott, 1894)	2	CMN, USNM	309
Metridia lucens Boeck, 1864	17	USNM	106, 309
Metridia okhotensis Brodsky, 1950	7	USNM	106, 142, 309
Metridia pacifica Brodsky, 1950	13		142, 171
Metridia princeps Giesbrecht, 1892	2	CMN, USNM	309
Pleuromamma sp.	2		106
Pleuromamma abdominalis (Lubbock, 1856)	2	USNM	309
Pleuromamma borealis (Dahl, 1893)	1	USNM	309
Pleuromamma quadrungulata (Dahl, 1893)	1	USNM	309
Pleuromamma scutullata Brodsky, 1950	10	CMN	157
Pleuromamma xiphias (Giesbrecht, 1889)	1		157
Family Paracalanidae			
Paracalanus parvus (Claus, 1863)	33		106, 142, 171, 291

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Scolecithricidae			
Lophothrix frontalis Giesbrecht, 1895	2	CMN	157
Scaphocalanus brevicornis (Sars, 1900)	4		142
Scaphocalanus echinatus (Farran, 1905)	2	USNM	291, 309
Scolecithricella dentata (Giesbrecht, 1892)	1	USNM	309
Scolecithricella minor (Brady, 1883)	11	USNM	106, 142, 257, 309
Scolecithricella subdentata (Esterley, 1905)	1		106
Family Spinocalanidae			
Spinocalanus brevicaudatus Brodsky, 1950	4		142
Suborder Heterarthrandria			
Family Acartiidae			
Acartia sp.	23		142
?*Acartia clausi* Giesbrecht, 1889	49		106
Acartia longiremis (Lilljeborg, 1853)	83		106, 142, 171, 229, 257
Family Arietellidae			
Arietellus simplex Sars, 1905	1	USNM	309
Family Augaptilidae			
Pachyptilus eurygnathus Sars, 1920	1	USNM	309
Pachyptilus pacificus Johnson, 1936	1	CMN	
Pontoptilus abbreviatus (Sars, 1905)	1	USNM	309
Family Candaciidae			
Candacia bipinnata (Giesbrecht, 1889)	1		157
Candacia columbiae Campbell, 1929	3		106, 142
Family Centropagidae			
Centropages abdominalis Sato, 1913	68		106, 142, 171, 257
Centropages bradyi Wheeler, 1900	2		142
Centropages hamatus (Lilljeborg, 1853)	2		229
Family Heterorhabdidae			
Heterorhabdus sp.	2		106
Heterorhabdus papilliger (Claus, 1863)	2	USNM	309
?*Heterorhabdus tanneri* (Giesbrecht, 1895)	1		106
Heterstylites longicornis (Giesbrecht, 1889)	1		157
Family Lucicutiidae			
Lucicutia flavicornis (Claus, 1863)	2		157
Family Pontellidae			
Epilabidocera sp.	2	RBCM	
Epilabidocera longipedata (Sato, 1913)	23		106, 142, 229, 257
Family Temoridae			
Eurytemora affinis (Poppe, 1880)	4		106
Family Tortanidae			
Tortanus discaudatus (Thompson & Scott, 1897)	72	USNM	106, 142, 229, 257, 309
Order Harpacticoida			
Suborder Oligarthra			
Infraorder Maxillipedasphalea			
Superfamily Cervinioidea			

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Aegisthidae			
Aegisthus sp.	1		142
Superfamily Ectinosomatoidea			
Family Ectinosomidae			
Ectinosomidae	12		291
Microsetella norvegica (Boeck, 1864)	35		106
Microsetella rosea (Dana, 1848)	6		106
Infraorder Exanechentera			
Superfamily Tachidioidea			
Family Harpactidae			
Harpacticus sp.	1		65
Tigriopus californicus Baker, 1912	8		160
Family Tachidiiae			
Microarthriodion littorale (Poppe, 1881)	6		291
Tachidius discipes Giesbrecht, 1881	4		291
Family Tisbidae			
Tisbe sp.	3		291
Infraorder Podogennonta			
Superfamily Ameiroidea			
Family Ameiridae			
Nitocra sp.	2		291
Family Canthocamptidae			
Mesochra pygmaea (Claus, 1863)	3		291
Superfamily Cletodoidea			
Family Cletodidae			
Huntemannia jadensis Poppe, 1884	11		291
Nannopus palustris Brady, 1880	2		291
Family Laophontidae			
Heterolaophonte discophora (Willey, 1929)	3		291
Onychocamptus mohammed (Blanchard & Richard, 1891)	1		291
Superfamily Metoidea			
Family Cylindropsyllidae			
Cylindropsyllidae	2		291
Stenocaris sp.	1		291
Family Diosaccidae			
Diosaccidae	3		291
Amphiascus minutus (Claus, 1863)	3		291
Diosaccus sp.	3		65, 66, 291
Schizopera knabeni Lang, 1965	4		291
Stenhelia asetosa Thistle & Coull, 1979	8		291
Family Thalestridae			
Dactylopodia sp.	1		291
Order Cyclopoida			
Family Bomolochidae			
Holobomolochus venustus Kabata, 1971	1		280

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Corycaeidae			
Corycaeus affinis McMurrich, 1916	17		106
Corycaeus anglicus Lubbock, 1857	6		142
Family Cyclopidae			
Halicyclops sp.	3		291
Family Oithonidae			
Oithona plumifera Baird, 1843	10		106
Oithona spinirostris Claus, 1863	118	USNM	106, 142, 171, 229, 309
Family Oncaeidae			
Oncaea sp.	1		257
Oncaea conifera Giesbrecht, 1891	33		106
Pseudolubbockia dilatata Sars, 1909	9		175
Family Rataniidae			
Ratania atlantica Farran, 1926	5	USNM	175
Order Poecilostomatida			
Family Chondracanthidae			
Acanthochondria hippoglossi Kabata, 1987	1		73
Chondracanthus pinguis Wilson, 1912	3		277, 278, 280
Chondracanthus triventricosus Sekerak, 1970	3		277, 278, 280
Family Philichthyidae			
Colobomatus kyphosus Sekerak, 1970	3		277, 278, 280
Sarcotaces arcticus Collett, 1874	1		280
Order Siphonostomatoida			
Family Caligidae			
Lepeophtheirus sp.	1	USNM	
Lepeophtheirus bifidus Fraser, 1920	1		73
Lepeophtheirus hospitalis Fraser, 1920	1		73
Lepeophtheirus oblitus Kabata, 1973	1		280
Lepeophtheirus parvipes Wilson, 1912	1		73
Lepeophtheirus parviventris Wilson, 1915	1		73
Lepeophtheirus paulus Cressey, 1969	1		280
Lepeophtheirus salmonis Kröyer, 1938	1	USNM	
Family Lernaeopodidae			
Clavella parva Wilson, 1912	3		277, 278, 280
Neobrachiella robusta (Wilson, 1912)	3		277, 278, 280
Family Naobranchiidae			
Naobranchia occidentalis Wilson, 1915	1		280
Family Pennellidae			
Haemobaphes theragrae Yamaguti, 1939	1		280
Peniculus asimus Kabata & Wilkes, 1978	1		280
Family Pontoeciellidae			
Pontoeciella abyssicola (Scott, 1894)	1		175
Class Ostracoda			
Subclass Myodocopa			
Order Myodocopina			
Family Cylindroleberididae			

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Bathyleberis sp.	4		98
Cylindroleberis cf. *mariae* (Baird, 1850)	1		65
Family Rutidermatidae			
Rutiderma sp.	6	RBCM	98
Suborder Myodocopina			
Family Philomedidae			
Euphilomedes sp.	1		65
Euphilomedes carcharodonta (Smith, 1952)	1		98
Euphilomedes producta Poulsen, 1962	5		98
Philomedes sp.	2		142
Scleroconcha trituberculata (Lucas, 1931)	3	ROM	98
Order Halocyprida			
Suborder Halocypridina			
Family Halocyprididae			
Conchoecia sp.	1		257
Class Cirripedia			
Order Thoracica			
Suborder Lepadomorpha			
Family Lepadidae			
Conchoderma auritum (Linnaeus, 1767)	1	CAS	
Conchoderma virgatum (Splenger, 1790)	1		15
Lepas sp.	3		268
Lepas anatifera Linnaeus, 1758	5	RBCM, USNM	172
Lepas fascicularis (Ellis & Solander, 1786)	2	CAS, USNM	172
Lepas hillii (Leach, 1818)	2	RBCM	
Lepas pacifica Henry, 1940	5	RBCM, USNM	172
Family Scalpellidae			
Scalpellidae	1	RBCM	
Pollicipes polymerus (Sowerby, 1833)	41	RBCM	8, 9, 10, 12, 13, 16, 20, 160, 161, 268, 276
Trianguloscapellum regium (Wyville Thompson, 1877)	1	USNM	
Suborder Balanomorpha			
Family Archaeobalanidae			
Semibalanus cariosus (Pallas, 1788)	133	CAS, RBCM, USNM	8, 9, 10, 12, 13, 21, 65, 160, 161, 173, 238, 268, 271, 275, 276, 296, 297, 298
Solidobalanus hesperius (Pilsbry, 1916)	19	CAS, RBCM, ROM, USNM	98, 173
Family Balanidae			
Balanidae	2	ROM	98
Balanus sp.	22	RBCM	1, 259, 268
Balanus balanus (Linnaeus, 1758)	6	USNM	123, 173, 268
Balanus crenatus Bruguiere, 1789	22	CAS, RBCM, ROM	18, 98, 160, 161, 173
Balanus glandula Darwin, 1854	132	RBCM	9, 10, 13, 16, 160, 161, 173, 238, 275, 276, 296, 297, 298, 305
Balanus nubilus Darwin, 1854	44	RBCM	8, 10, 11, 14, 16, 20, 160, 193, 259, 260, 275, 276, 297, 298

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Balanus rostratus Hoek, 1833	2	RBCM	
Balanus trigonus Darwin, 1854	1		15
Family Chthamalidae			
Chthamalus sp.	10		16, 21, 268
Chthamalus dalli Pilsbry, 1916	65		160, 161, 238, 296, 297, 298
Family Coronulidae			
Subfamily Coronulina			
Coronula diadema (Linnaeus, 1767)	1		15
Coronula reginae Darwin, 1854	1		15
Cryptolepas rachianecti Dall, 1872	1		15
Subfamily Xenobalaninae			
Xenobalanus globiciptis Steenstrup, 1851	1		15
Order Rhizocephala			
Suborder Kentrogonida			
Family Peltogastridae			
Trachelosaccus hymenodorae (Sars, 1879)	1		104
Family Sylonidae			
Sylon hippolytes Sars, 1870	1		104
Suborder Akentrogonida			
Family Akentrogonidae			
Mycetomorpha sp.	1	RBCM	
Class Malacostraca			
Subclass Phyllocarida			
Order Leptostraca			
Family Nebaliidae			
Nebaliidae	3		98
Nebalia pugettensis (Clark, 1932)	4	ROM	98, 160, 298
Subclass Peracarida			
Order Mysidacea			
Suborder Lophogastrida			
Family Eucopiidae			
Eucopia unguiculata (Willemoes-Suhm, 1875)	3	USNM	32, 292
Family Lophogastridae			
Gnathophausia sp.	2		311
Gnathophausia gigas Willemoes-Suhm, 1875	8	RBCM, USNM	32, 255, 292
Suborder Mysida			
Family Petalophthalmidae			
Ceratomysis spinosa Faxon, 1893	1	USNM	292
Suborder Mysina			
Family Mysidae			
Alienacanthomysis macropsis (Tattersall, 1932)	3	CMN	183, 184
Amblyops abbreviata (Sars, 1869)	2		32
Archaeomysis grebnitzkii Czerniavsky, 1882	12	CMN, USNM	182, 184
Boreomysis californica Ortman, 1894	3	USNM	32, 35, 292

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Boreomysis inermis (Willemoes-Suhm, 1874)	2	USNM	292
Boreomysis microps Sars, 1884	1		32
Euchaetomera tenuis Sars, 1883	3		32
Exacanthomysis davisi (Banner, 1948)	3	CMN	182, 184
Holmesiella anomala Ortmann, 1908	11	USNM	32, 292
Holmesimysis costata (Holmes, 1900)	6	CMN	180, 184
Holmesimysis nuda (Banner, 1948)	8	CMN	180, 184
Holmesimysis nudensis Holmquist, 1979	2	CMN, USNM	180, 184
Holmesimysis sculpta (Tattersall, 1933)	1	CMN	180, 184
Holmesimysis sculptoides Holmquist, 1979	1	CMN	180, 184
Inusitatomysis insolita Ii, 1940	3	CMN	33, 184
Mysidella americana Banner, 1948	1	USNM	33, 35, 203
Neomysis mercedis Holmes, 1896	7	CMN	179, 184
Neomysis rayi (Murdoch, 1885)	3	CMN, USNM	184
?*Pseudomma truncatum* Smith, 1879	1	USNM	292
?*Xenacanthomysis pseudomacropsis* (Tattersall, 1933)	1		181
Subfamily Mysinae			
Tribe Mysini			
Columbiaemysis ignota Holmquist, 1982	1	CMN	184
Pacifacanthomysis nephrophthalma (Banner, 1948)	4	CMN, USNM	33, 35, 183, 184
Subfamily Rhopalophthalminae			
Tribe Mysinae			
Caesaromysis hispida Ortmann, 1893	2	USNM	32, 35
Euchaetomeropsis pacifica Banner, 1948	2	USNM	32
Meterythrops robusta Smith, 1879	2		32
Teraterythrops robusta (Berstein & Tchindonova, 1958)	1		32
Order Cumacea			
Family Bodotriidae			
Vaunthompsonia sp.	2		98
Family Diastylidae			
Diastylidae	1		98
Diastylis sp.	10		65, 98
Diastylis dalli Calman, 1912	3		98
Diastylis paraspinulosa Zimmer, 1926	1		98
Diastylis pellucida Hart, 1930	1		98
Diastylopsis sp.	1		98
Diastylopsis dawsoni Smith, 1879	12	ROM, YPM	98, 160, 162, 286
Diastylopsis tenuis Zimmer, 1936	3		98
Family Leuconidae			
Eudorella sp.	2		65, 66
Eudorella pacifica Hart, 1930	12		98, 160
Eudorellopsis longirostris Given, 1962	6		98
Leucon sp.	2		65, 98
Family Nannastacidae			
Campylaspis sp.	2		98
Campylaspis canaliculata Zimmer, 1936	2		98
Campylaspis rubromaculata Lie, 1970	1		98
Cumella sp.	1		98
Cumella vulgaris Hart, 1930	2		291

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Order Tanaidacea			
Suborder Tanaidomorpha			
Family Paratanaidae			
Araphura brevimana (Lilljeborg, 1864)	1		7
Leptochelia savignyi Kröyer, 1842	5	CMN, RBCM	298
Leptognathia sp.	3		98
Family Tanaidae			
Tanais sp.	1		286
Zeuxo normani (Richardson, 1905)	2	CMN	298
Order Isopoda			
Suborder Gnathiidea			
Family Gnathiidae			
Gnathia sp.	3	ROM	98
Gnathia trilobata *Schultz, 1966*	11	ROM	98
Suborder Flabellifera			
Family Aegidae			
Rocinela sp.	4	RBCM	95
Rocinela angustata Richardson, 1904	2		98, 170
Rocinela belliceps (Stimpson, 1864)	12	RBCM	18, 170
Family Cirolanidae			
Cirolana aff. *californiensis* Schultz, 1966	1		15
Cirolana harfordi Stafford, 1912	36	CMN, RBCM	160
Family Cymothoidae			
Lironeca californica Schiödte & Meinert, 1883-84	1		96
Family Limnoriidae			
**Limnoria lignorum* Rathke, 1799			72
Family Sphaeromatidae			
Exosphaeroma amplicauda (Stimpson, 1857)	10	CMN	
Exosphaeroma rhomburum (Richardson, 1899)	6	CMN	
Gnorimosphaeroma sp.	4	RBCM	268, 298
Gnorimosphaeroma insulare (Van Name, 1940)	4		16, 160, 298
Gnorimosphaeroma oregonense (Dana, 1853)	42	CMN, RBCM	16, 160, 297
Sphaeroma sp.	1		286
Suborder Asellota			
Family Jaeropsididae			
Jaeropsis dubia Menzies, 1951	1	ROM	98
Family Janiridae			
Janiralata solasteri (Hatch, 1947)	3	ROM	98, 170
Suborder Valvifera			
Family Idoteidae			
Idotea sp.	30	RBCM	10, 160, 268, 271, 297
Idotea fewkesi Richardson, 1905	6	CMN, RBCM	264
Idotea montereyensis Maloney, 1933	17	CMN	16, 160, 264
Idotea obscura Rafi, 1972	6	CMN	263, 264
Idotea ochotensis Brandt, 1851	5	RBCM	263, 297
Idotea resecata Stimpson, 1857	13	CMN, RBCM	268

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Idotea rufescens Fee, 1927	3	CMN	
Idotea schmitti Menzies, 1950	2	CMN	
Idotea stenops Benedict, 1898	1		160
Idotea urotoma Stimpson, 1864	17	CMN, RBCM, USNM	297
Idotea wosnesenskii Brandt, 1851	23	CMN, RBCM	160, 161, 170, 268, 297
Synidotea sp.	1	CMN	
Synidotea bicuspida (Owen, 1839)	1	CMN	
Synidotea consolidata Stimpson, 1856	1	CMN	264
Synidotea cornuta Rafi & Laubitz, 1990	1	CMN	264
Synidotea media Iverson, 1972	2	ROM	98
Synidotea minuta Rafi & Laubitz, 1990	3	CMN	264
Synidotea nebulosa Benedict, 1897	9	ROM	98
Synidotea nodulosa (Kröyer, 1848)	10	ROM, YPM	98, 286
Synidotea picta Benedict, 1897	1	ROM	98
Synidotea ritteri Richardson, 1904	1	CMN	
Suborder Epicaridea			
Family Bopyridae			
Argeia sp.	1	RBCM	
Argeia pugettensis Dana, 1853	1		104
Bopyroides hippolytes (Kroyer, 1838)	1		104
Hemiarthrus abdominalis (Kröyer, 1840)	2	USNM	104
Munidion parvum Richardson, 1904	1	RBCM	
Prophryxus alascensis Richardson, 1909	1	USNM	270
Family Dajidae			
Arthrophryxus beringanus Richardson, 1908	1	USNM	270
Holophryxus alaskensis Richardson, 1905	2	RBCM	104
Suborder Oniscoidea			
Family Ligiidae			
Ligia sp.	1		268
Ligia pallasi Brandt, 1833	17	RBCM	160, 170
Ligidium gracile (Dana, 1856)	3	RBCM	170
Family Oniscidae			
Porcellio scaber Latreille, 1804	10	RBCM	170
Order Amphipoda			
Suborder Gammaridea			
Superfamily Lysianassoidea			
Family Cyphocarididae			
Cyphocaris sp.	4		142
Cyphocaris challengeri Stebbing, 1888	3	RBCM, USNM	
Metacyphocaris helgae Tattersall, 1906	1		299
Family Lysianassidae			
Lysianassidae	16	ROM	98
Eurystheus fusiformis unk	1	CMN	
Eurystheus grillus Lichenstein, 1822	6	CMN	

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Taxon	Observations Recorded	Museum Collections	References in Appendix E
Subfamily Lysianassinae			
Dissiminassa dissimilis (Stout, 1913)	1		271
Subfamily Tryphosinae			
Koroga megalops Homes, 1908	1		38
Lepidepecreum sp.	15	CMN, ROM	98, 160
Orchomene sp.	8	CMN, RBCM, ROM	98, 142, 297, 298
Orchomene abyssorum (Stebbing, 1888)	1	CMN	
Orchomene pinguis (Boeck, 1861)	1	CMN	
Orchomenella decipiens (Hurley, 1963)	1	CMN	
Psammonyx longimerus Jarrett & Bousfield, 1982	2	RBCM	297
Family Opisidae			
Opisa odontochela Bousfield, 1987	1		79
Opisa tridentata Hurley, 1963	2		73, 79
Pachynus sp.	6	ROM	98
Pachynus barnardi Hurley, 1963	2		98
Family Scopelocheiridae			
Paracallisoma alberti Stebbing, 1888	2	CMN	
Paracallisoma coecus (Holmes, 1908)	1		38
Family Uristidae			
Anonyx sp.	4		18, 19
Anonyx lilljeborgi Boeck, 1871	1		299
Euonyx sp.	1	CMN	
Superfamily Stegocephaloidea			
Family Stegocephalidae			
Stegocephalxia penelope Moore, 1992	2	CMN	244
Subfamily Adanieniexinae			
Parandania boecki (Stebbing, 1888)	4	CMN	244
Superfamily Pardaliscoidea			
Family Pardaliscidae			
Nicippe sp.	2	ROM	98
Nicippe tumida Bruzellius, 1859	13		98
Family Stilipedidae			
Subfamily Stilipedinae			
Stilipes sp.	1		257
Superfamily Synopioidea			
Family Synopiidae			
Tiron biocellata Barnard, 1962	13	CMN, ROM	98
Suborder Hyperiidea			
Infraorder Physosomata			
Superfamily Scinoidea			
Family Scinidae			
Scina sp.	2	USNM	
Scina borealis (Sars, 1882)	1		299
Scina rattrayi Stebbing, 1895	2	USNM	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Infraorder Physocephalata			
Superfamily Vibilioidea			
Family Cystosomatidae			
Cyctosoma fabricii Stebbing, 1888	1	USNM	
Cyctosoma pellucidus (Willemoes-Suhm, 1873)	1		299
Family Paraphronimidae			
Paraphronima gracilis Claus, 1879	3		171
Family Vibiliidae			
Vibilia propingua Stebbing, 1888	5		171
Superfamily Phronimoidea			
Family Hyperiidae			
Hyperia sp.	6	USNM	142, 171
Hyperia medusarum (Müller, 1776)	6	USNM	171
Hyperia medusarum hystrix unk	6	USNM	
Hyperoche mediterranea Senna	5	USNM	
Hyperoche medusarum (Kröyer, 1842)	12	USNM	171, 299
Parathemisto sp.	20		99, 142, 257
Themisto pacifica (Stebbing, 1888)	12	USNM	90, 171
Family Phronimidae			
Phronima sp.	2	RBCM	142
Phronima sedentaria (Forskal, 1775)	4	RBCM	171, 299
Family Phrosinidae			
Primno sp.	1		99
Primno abyssalis (Bowman, 1968)	11	USNM	171, 299
Superfamily Platysceloidea			
Family Lycaeidae			
Brachyscelus sp.	1		171
Brachyscelus crusculum Bate, 1861	4		171
Tryphana malmi Boeck, 1870	8	USNM	
Family Oxycephalidae			
Streetsia pronoides (Bovallius, 1887)	8	USNM	
Superfamily Phoxocephaloidea			
Family Phoxocephalidae			
Phoxocephalidae	2	ROM	98, 271
Subfamily Brolginae			
Eobrolgus sp.	2	RBCM	
Eobrolgus chumashi Barnard & Barnard, 1982	5	CMN	189
Subfamily Harpiniinae			
Heterophoxus sp.	1	ROM	
Heterophoxus affinis Holmes, 1908	21	CMN, ROM	82, 98, 160
Heterophoxus conlanae Jarrett & Bousfield, 1994	3	CMN	189
Heterophoxus ellisi Jarrett & Bousfield, 1994	1	CMN	189
Heterophoxus ellisi, variant Jarrett & Bousfield, 1994	2	CMN	189

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Subfamily Metharpiniinae			
Foxiphalus sp.	3	ROM	98
Foxiphalus falciformis Jarrett & Bousfield, 1994	2	CMN	188
Foxiphalus obtusidens Alderman, 1936	34	ROM	98
Foxiphalus similus (Barnard, 1960)	8	CMN	188
Foxiphalus xiximeus Barnard & Barnard, 1982	7	CMN	188
Grandifoxus sp.	29	ROM	98
Grandifoxus dixonensis Jarrett & Bousfield, 1994	1	CMN	188
Grandifoxus grandis (Stimpson, 1857)	7	CMN	
Majoxiphalus major (Barnard, 1960)	2	CMN	188
Rhepoxynius sp.	24		98, 160
Rhepoxynius abronius Barnard, 1960	3	CMN	188
Rhepoxynius episburi unk	3		98
Rhepoxynius pallidus (Barnard, 1960)	1	CMN	188
Subfamily Phoxocephalinae			
Parametaphoxus sp.	1	ROM	98
Parametaphoxus quaylei Jarrett & Bousfield, 1994	1		98
Superfamily Eusiroidea			
Family Calliopiidae			
Calliopius sp.	6	RBCM	142, 257
Calliopius columbianus Bousfield & Hendrycks, 1997	1	CMN	85
Calliopius pacificus Bousfield & Hendrycks, 1997	6	CMN	85
Oligochinus lighti Barnard, 1969	2	CMN	85
Paracalliopiella pratti Barnard, 1954	19	CMN	85
Family Eusiridae			
Eusirella multicalceola (Thorsteinson, 1941)	6	CMN	38, 84, 299
Rhachotropis sp.	3		98
Rhachotropis americana Bousfield & Hendrycks, 1995	2	CMN	84
Rhachotropis calceolata Bousfield & Hendrycks, 1995	1	CMN	84
Rhachotropis distincta (Holmes, 1908)	1	CMN	84
Rhachotropis natator (Holmes, 1908)	6	CMN	38, 84, 299
Family Pontogeneiidae			
Paramoera sp.	5	RBCM	298
Paramoera bousfieldi Staude, 1995	4	CMN, RBCM	288, 289, 297
Paramoera carlottensis Bousfield, 1958	2	CMN	76, 288, 289
Paramoera columbiana Bousfield, 1958	9	CMN	76, 288, 289
Paramoera suchaneki Staude, 1995	1	CMN	288, 289
?*Pontogeneia intermedia* Gurjanova, 1938	4	RBCM	298
Superfamily Oedicerotoidea			
Family Oedicerotidae			
Oedicerotidae	4	ROM	98
Americhelidium sp.	2	ROM	98
Americhelidium rectipalmum (Mills, 1962)	8	CMN, ROM	81, 98, 240
Americhelidium shoemakeri Mills, 1962	20	CMN, ROM	81, 98, 240
Monculodes perditus Barnard, 1966	1	CMN	81
Pacifoculodes spinipes (Mills, 1962)	2	CMN	81, 240
Pacifoculodes zernovi (Gurjanova, 1936)	2	CMN	81, 240
Westwoodilla caecula (Bate, 1856)	3	CMN	240

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Superfamily Leucothoidea			
Family Leucothoidae			
Leucothoe spinicarpa Abildgaard, 1789	4	CMN	8
Family Pleustidae			
Subfamily Parapleustinae			
Chromopleustes lineatus Bousfield & Hendrycks, 1995	1		83
Chromopleustes oculatus (Holmes, 1908)	4	CMN	83
Gnathopleustes sp.	7	ROM	98
Gnathopleustes pachychaetus Bousfield & Hendrycks, 1995	4	CMN	
Gnathopleustes pugettensis (Dana, 1853)	3	CMN	83, 282
Gnathopleustes serratus Bousfield & Hendrycks, 1995	3	CMN	83
Micropleustes nautilus (Barnard, 1969)	4	CMN	83
Trachypleustes trevori Bousfield & Hendrycks, 1994	1	CMN	83
Subfamily Pleusirinae			
Pleusirus secorrus Barnard, 1969	10	CMN	83
Subfamily Pleustinae			
Pleustes sp.	2	RBCM	271
Pleustes victoriae Bousfield & Hendrycks, 1994	1	CMN	82
Thorlaksonius brevirostris Bousfield & Hendrycks, 1994	3	CMN	82
Thorlaksonius carinatus Bousfield & Hendrycks, 1994	1	CMN	82
Thorlaksonius grandirostris Bousfield & Hendrycks, 1994	2	CMN	82
Thorlaksonius subcarinatus Bousfield & Hendrycks, 1994	8	CMN	82
Superfamily Stenothoidea			
Family Amphilochidae			
Subfamily Amphilochinae			
Apolochus litoralis (Stout, 1912)	1	CMN	185
Apolochus staudei Hoover & Bousfield, 2001	1	CMN	185
Hourstonius vilordes (Barnard, 1962)	1	CMN	185
Superfamily Iphimedioidea			
Family Iphimedidae			
Iphimedia rickettsi (Shoemaker, 1931)	1	CMN	244
Family Lafystiidae			
Paralafystius mcallisteri Bousfield, 1987	1		79
Protolafystius madillae Bousfield, 1987	1		79
Family Odiidae			
Cryptodius kelleri (Brüggen, 1907)	1	CMN	244
Odius cf. *carinatus* (Bate, 1862)	1	CMN	
Superfamily Dexaminoidea			
Family Atylidae			
Subfamily Atylinae			
Atylus borealis Bousfield & Kendall, 1994	3	CMN	88
Atylus georgianus Bousfield & Kendall, 1994	1	CMN	88, 239
Atylus levidensus (Barnard, 1936)	12	CMN	88, 239
Atylus tridens (Alderman, 1936)	9	CMN	88, 239

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Dexaminidae			
Subfamily Prophliantinae			
Guernea reduncans (Barnard, 1958)	2	CMN	88
Superfamily Ampeliscoidea			
Family Ampeliscidae			
Ampelisca sp.	6	ROM	23, 98
Ampelisca agassizi (Judd, 1896)	11	CMN, ROM, USNM	98, 140
Ampelisca brevisimulata Barnard, 1954	2	CMN	140
Ampelisca careyi Dickinson, 1982	1	CMN	140
Ampelisca cristata Holmes, 1908	7	ROM	98
Ampelisca hancocki Barnard, 1954	1	ROM	98
Ampelisca hessleri Dickinson, 1982	3	CMN, USNM	140
Ampelisca lobata Holmes, 1908	6	CMN	140
Ampelisca macrocephala Liljeborg, 1842	43	ROM	98, 160
Ampelisca pugetica Stimpson, 1864	8	CMN	140
Ampelisca unsocolae Barnard, 1960	2	CMN	140
Byblis sp.	6	RBCM, ROM	98, 141
Byblis gaimardii (Kröyer, 1846)	11	ROM	98
Byblis millsi Dickinson, 1983	2	CMN	141
Byblis mulleni Dickinson, 1983	2	CMN	141
Byblis pearcyi Dickinson, 1983	10		98, 160
Byblis thyablis Barnard, 1971	1	RBCM	141
Byblis veleronis Barnard, 1954	1	CMN	141
Haploops tubicola Liljeborg, 1856	14	CMN, ROM	98, 141
Superfamily Melphidippoidea			
Family Melphidippidae			
Melphidippa sp.	2	CMN	142
Superfamily Crangonyctoidea			
Family Crangonyctidae			
Crangonyx richmondensis occidentalis (Hubricht & Harrison, 1941)	6		76
Superfamily Talitroidea			
Family Hyalellidae			
Allorchestes angusta Dana, 1853	3	RBCM	297, 298
Allorchestes urocarinatus Bousfield, 1981	7	CMN	
Subfamily Hyalellinae			
Hyalella azteca (Saussure, 1858)	1		76
Family Hyalidae			
Apohyale pugettensis (Dana, 1853)	5	CMN	
Parallorchestes sp.	4	RBCM	298
Parallorchestes ocholensis (Brandt, 1851)	14	CMN	271
Plumulohyale plumulosa (Stimpson, 1857)	6	CMN	271
Protohyale frequens (Stout, 1913)	5	CMN	271
Protohyale seticornis (Bousfield, 1981)	2	CMN	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Najnidae			
Najna sp.	1		9
Najna bicarinata unk	2	CMN	
Najna rugosum Bousfield, 1981	1	CMN	
Family Talitridae			
Talitridae	4		160
Megalorchestia californiana (Brandt, 1851)	1	CMN	75
Megalorchestia columbiana (Bousfield, 1958)	2	CMN	78
Megalorchestia pugettensis (Dana, 1853)	14	CMN, RBCM	78
Orchestia sp.	1	CMN	
Traskorchestia georgiana (Bousfield, 1958)	1	CMN	78
Traskorchestia traskiana (Stimpson, 1854)	25	CMN, RBCM	75, 78, 296, 297
Superfamily Pontoporeioidea			
Family Haustoridae			
Eohaustorius estuarius Bosworth, 1973	3	CMN	86
Eohaustorius washingtonianus (Thorsteinson, 1941)	9	CMN	86
Superfamily Gammaroidea			
Family Anisogammaridae			
Anisogammarus pugettensis Dana, 1853	4	CMN	77
Anisogammarus pugettensis pugettensis Dana, 1853	1	CMN	80
Eogammarus confervicolus (Stimpson, 1856)	26	CMN	76, 77
Locustogammarus sp.	1	CMN	
Locustogammarus levingsi Bousfield, 1979	6	CMN, USNM	77
Locustogammarus locustoides (Brandt, 1851)	11	CMN	76, 77
Ramellogammarus columbianus Bousfield & Morino, 1992	3	CMN	76, 77, 89
Family Gammaridae			
Gammaridae	1		99
Elasmopus antennatus (Stout, 1913)	1	CMN	
Melita sp.	8	CMN, ROM	65, 98
Melita cf. *nitida* Smith, 1874	1	CMN	
Melita oregonensis Barnard, 1954	8	CMN	190
Melita cf. *oregonensis* Barnard, 1954	3	CMN	
Superfamily Hadzioidea			
Family Melitidae			
Desdimelita californica (Alderman, 1936)	15	CMN	271
Desdimelita microdentata Jarrett & Bousfield, 1996	5	CMN	190
Maera sp.	2	RBCM	271, 298
Maera fusca (Bate, 1864)	1	USNM	201
Maera jerrica Krapp-Schickel & Jarrett, 2000	1	CMN	
Maera similis Stout, 1913	3	RBCM	298
Megamoera bowmani Jarrett & Bousfield, 1996	1	CMN	190
Megamoera dentata Jarrett & Bousfield, 1996	1	CMN	
Megamoera subtener (Stimpson, 1864)	10	CMN	190
Quadrimaera carla Krapp-Schickel & Jarrett, 2000	1	CMN	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Superfamily Corophioidea			
Family Ampithoidae			
Ampithoe sp.	1	RBCM	298
Ampithoe dalli Shoemaker, 1938	17	CMN, RBCM	120, 297
Ampithoe kussakini Gurjanova, 1955	16	CMN, RBCM	120
Ampithoe lacertosa Bate, 1858	23	CMN, RBCM	120, 298
Ampithoe sectimanus Conlan & Bousfield, 1982	3	CMN	120
Ampithoe setosa Stout	4	CMN	
Ampithoe simulans Alderman, 1936	2	CMN	120
**Ampithoe valida* Smith, 1873	6	CMN, RBCM	297
Cymadusa uncinata Stout, 1912	4	CMN, RBCM	120
Peramphithoe eoa Barnard, 1854	1		271
Peramphithoe humeralis (Stimpson, 1864)	11	CMN, RBCM	120, 297
Peramphithoe lindbergi Gurjanova, 1938	7	CMN, RBCM	120, 297
Peramphithoe plea (Barnard, 1965)	1	CMN	120
Peramphithoe tea (Barnard, 1965)	9	CMN, RBCM	120, 297, 298
Family Aoridae			
Aoroides columbiae Walker, 1898	10	CMN	121
Aoroides exilis Conlan & Bousfield, 1982	12	CMN	121
Aoroides intermedius Conlan & Bousfield, 1982	8	CMN	121
Aoroides spinosus Conlan & Bousfield, 1982	15	CMN	121
**Neohela monstrosa* Boeck, 1861	1	CMN	
Family Corophiidae			
Subfamily Corophiinae			
Americorophium brevis (Shoemaker, 1949)	1	CMN	87
Americorophium salmonis (Stimpson, 1857)	5	CMN	87, 291
Americorophium spinicorne (Stimpson, 1857)	17	CMN	76, 87
Crassicorophium crassicorne (Bruzelius, 1859)	2	CMN	87
Laticorophium baconi (Shoemaker, 1934)	1	CMN	87
Monocorophium carlottensis Bousfield & Hoover, 1997	6	CMN	87
Monocorophium steinegeri (Gurjanova, 1951)	1	CMN	87
Family Isaeidae			
Gammaropsis ellisi Conlan, 1983	4	CMN, RBCM	118, 298
Gammaropsis thompsoni (Walker, 1898)	4	CMN	118
Megamphopus sp.	2	RBCM	297
Photis sp.	12	RBCM, ROM	65, 66, 98, 297
Photis bifurcata Barnard, 1962	2	CMN	118, 298
Photis brevipes Shoemaker, 1942	35	CMN, ROM	98, 118, 160
Photis pachydactyla Conlan, 1983	1	CMN	118
Photis cf. *spasskii* Gurjanova, 1951	1	CMN	118
Protomedeia sp.	23	ROM	98
Protomedeia grandimana Bruggen, 1906	2		98, 160
Protomedeia prudens Barnard, 1966	1	CMN	118
Family Ischyroceridae			
Ischyroceridae	1	ROM	
**Erichthonius brasiliensis* Dana, 1853	1	CMN	
Erichthonius difformis Milne-Edwards, 1830	1	CMN	
Ischyrocerus sp.	12	CMN, RBCM, ROM	98, 271, 297

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Ischyrocerus anguipes Kröyer, 1838	2		98
Jassa slatteryi Conlan, 1990	1		119
Jassa staudei Conlan, 1990	1		119
Family Podoceridae			
Dyopedos arcticus Murdoch, 1884	2	CMN	215
Dyopedos bispinis (Gurjanova, 1930)	1	CMN	215
Podocerus sp.	4	CMN	98
Suborder Caprellidea			
Superfamily Caprelloidea			
Family Caprellidae			
Caprellidae	3	ROM	271, 311
Caprella sp.	2	ROM	98
Caprella alaskana Mayer, 1903	6	CMN	214
Caprella angusta Mayer, 1903	2	CMN	214
Caprella borealis Mayer, 1903	5	CMN	214
Caprella californica Stimpson, 1857	5	CMN	214
Caprella equilibra Say, 1818	1		268
Caprella gracilior Mayer, 1903	1	CMN	214
Caprella incisa Mayer, 1903	1	CMN	214
Caprella irregularis Mayer, 1890	2	CMN	214
Caprella laeviuscula Mayer, 1903	17	CMN	98, 275
Caprella mendax Mayer, 1903	2	CMN	214
Caprella natalensis (Mayer, 1903)	1	CMN	
*_Caprella penantis_ Leach, 1814	1	CMN	
Caprella pustulata Laubitz, 1970	5	CMN, USNM	214
Caprella rudiuscula Laubitz, 1970	4	CMN	214
Caprella striata Mayer, 1903	2	CMN, RBCM	
Caprella ungulina Mayer, 1903	1	USNM	
Caprella verrucosa Boeck, 1872	3	CMN	214
Metacaprella anomala (Mayer, 1903)	1	CMN	214
Metacaprella ferresa Mayer, 1903	4	CMN	214
Metacaprella kennerlyi (Stimpson, 1864)	5	CMN	214
Perotripus brevis (La Follette, 1915)	3	CMN, USNM	214
Pseudoliropus vanus Laubitz, 1970	1	CMN	214
Tritella laevis Mayer, 1903	4	CMN	214
Tritella pilimana Mayer, 1890	3	CMN	214
Infraorder Cyamida			
Family Cyamidae			
Cyamus balaenopterae Barnard, 1931	1		219
Cyamus boopis Lütken, 1870	1		219
Cyamus catodontis Margolis, 1954	1		219
Cyamus ceti (Linnaeus, 1758)	1		219
Cyamus erraticus de Vauzeme, 1834	1		219
Cyamus eschrichtii Margolis, McDonald & Bousfield, 2000	1		219
Cyamus gracilis de Vauzeme, 1834	1		219
Cyamus kessleri Brandt, 1872	1		219
Cyamus mesorubraedon Margolis, McDonald & Bousfield, 2000	1		219

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Cyamus nodosus (Lütken, 1870)	1		219
Cyamus orubraedon Waller, 1989	1		219
Cyamus ovalis de Vauzeme, 1834	1		219
Isocyamus sp.	1		219
Isocyamus delphini (Guerin-Meneville, 1836)	1		219
Neocyamus physeteris (Pouchet, 1888)	1		219
Orcinocyamus orcini (Leung, 1970)	1		219
Platycyamus flaviscutatus Waller, 1989	1		219
Syncyamus sp.	2		218, 219
Subclass Eucarida			
Order Euphausiacea			
Family Bentheuphausiidae			
Bentheuphausia amblyops Sars, 1885	1		34
Family Euphausiacea			
Euphausiacea	9	RBCM	
Family Euphausiidae			
Euphausia sp.	1	RBCM	
Euphausia pacifica Hansen, 1911	29	ROM, USNM	34, 98, 99, 142, 155, 159, 171, 257
Nematobranchion flexipes (Ortmann, 1893)	2		34
Nematoscelis difficilis Hansen, 1911	2		34
Stylocheiron longicorne Sars, 1883	2		34, 74
Stylocheiron maximum Hansen, 1908	9		34
Tessarabrachion oculatum Hansen, 1911	3	USNM	34, 155, 159
Thysanoessa sp.	2		99
Thysanoessa inermis (Kröyer, 1846)	1		34
Thysanoessa inspinata Nemoto, 1963	5		171
Thysanoessa longipes Brandt, 1851	8		34, 142, 155
Thysanoessa raschi (Sars, 1854)	3		34, 257
Thysanoessa spinifera Holmes, 1900	23	ROM, USNM	34, 98, 99, 142, 155, 159, 171, 257
Thysanopoda acutifrons Holt & Tattersall, 1905	2	USNM	34, 35
Thysanopoda cornuta Illig, 1905	2	USNM	34, 159
Order Decapoda			
Suborder Dendrobranchiata			
Family Penaeidae			
Penaeidae	3	RBCM	
Bentheogennema borealis (Rathbun, 1902)	1		311
Bentheogennema burkenroadi Krygier & Wasmer, 1975	10	RBCM	311
Family Sergestidae			
Sergestes sp.	5	RBCM	171
Sergestes similis Hansen, 1903	13	RBCM	311
Suborder Pleocyemata			
Infraorder Caridea			
Family Alpheidae			
Betaeus harrimani Rathbun, 1904	3	RBCM	65, 298
Betaeus setosus Hart, 1964	1		166

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Crangonidae			
Argis sp.	1	RBCM	
Argis alaskensis (Kingsley, 1882)	4	RBCM	18
Argis crassa (Rathbun, 1899)	1		104
Argis levior (Rathbun, 1902)	1	RBCM	
Argis ovifer (Rathbun, 1902)	1		104
Crago sp.	2		10, 271
Crangon sp.	7	RBCM	95
Crangon abyssorum Rathbun, 1902	6	RBCM	104, 294, 311
Crangon alaskensis (Lockington, 1877)	10	ROM	18, 66, 98, 294
Crangon cf. *alaskensis* (Lockington, 1877)	1		65
Crangon alba Holmes, 1900	3	RBCM, ROM	98
Crangon dalli Rathbun, 1902	7		18, 19, 311
Crangon franciscorum Stimpson, 1859	1	RBCM	
Crangon franciscorum angustimana Rathbun, 1902	1		104
Crangon franciscorum franciscorum Stimpson, 1856	1	RBCM	
Crangon nigricauda Holmes, 1900	4	RBCM	271
Lissocrangon stylirostris (Holmes, 1900)	5	CMN, ROM	98, 271, 294
Metacrangon munita (Dana, 1852)	1	RBCM	
Metacrangon variabilis (Rathbun, 1902)	1		104
Neocrangon communis (Rathbun, 1899)	11	RBCM	18
Neocrangon resima (Rathbun, 1902)	6	RBCM	18
Paracrangon echinata Dana, 1852	2	RBCM	
Sclerocrangon boreas (Phipps, 1774)	1	RBCM	
Steiracrangon dalli (Rathbun, 1902)	1		18
Family Hippolytidae			
Hippolytidae	3		23, 298
Eualus sp.	7	RBCM	65, 66, 171
Eualus avinus (Rathbun, 1899)	3	RBCM	104
Eualus barbatus (Rathbun, 1899)	3	RBCM	18
Eualus biunguis (Rathbun, 1902)	15	RBCM, USNM	104, 150, 266, 311
Eualus fabricii (Kröyer, 1841)	2	RBCM	298
Eualus herdmani (Walker, 1898)	3	RBCM	298
Eualus lineatus Wicksten & Butler, 1983	3	RBCM	297, 308
Eualus macrophthalmus (Rathbun, 1902)	14	CMN	294, 311
Eualus pusiolus (Kröyer, 1841)	2	RBCM	18
Eualus suckleyi (Stimpson, 1864)	5	RBCM	18, 298
Heptacarpus sp.	16	RBCM	18, 23, 268, 269, 271, 297
Heptacarpus brevirostris (Dana, 1852)	8	RBCM	271
Heptacarpus carinatus Holmes, 1900	2	RBCM	104
Heptacarpus herdmani (Walker, 1898)	1		298
Heptacarpus kincaidi (Rathbun, 1902)	1	RBCM	
Heptacarpus littoralis Butler, 1980	2	CMN	104
Heptacarpus moseri (Rathbun, 1902)	7	CMN	294, 311
Heptacarpus paludicola Holmes, 1900	5	CMN, RBCM	104
Heptacarpus pugettensis Jensen, 1983	3	RBCM	297
Heptacarpus sitchensis (Brandt, 1851)	2	CMN	104
Heptacarpus stimpsoni Holthuis, 1947	3	RBCM	104, 298

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Heptacarpus stylus (Stimpson, 1864)	1	RBCM	
Heptacarpus tenuissimus Holmes, 1900	8	RBCM	18, 297
Heptacarpus tridens (Rathbun, 1902)	1		104
Hippolyte californiensis Holmes, 1895	2		207
Hippolyte clarki Chace, 1951	6	RBCM	297, 298
Lebbeus sp.	1		95
Lebbeus grandimana (Brazhnikov, 1907)	1		104
Lebbeus groenlandicus (Fabricius, 1775)	1		286
Lebbeus vicinus (Rathbun, 1902)	1	CMN	102
Lebbeus washingtonianus (Rathbun, 1902)	3		104, 311
Spirontocaris sp.	7	RBCM	65, 95, 271
Spirontocaris arcuata Rathbun, 1902	2	RBCM	18
Spirontocaris holmesi Holthuis, 1847	4	RBCM	18
Spirontocaris lamellicornis (Dana, 1852)	6	RBCM	18, 104
Spirontocaris ochotensis (Brandt, 1851)	2	CMN	104
Spirontocaris phippsi (Kröyer, 1841)	1	CMN	286
Spirontocaris prionota (Stimpson, 1864)	3	RBCM	104
Spirontocaris snyderi Rathbun, 1902	1		104
Spirontocaris spinus (Sowerby, 1805)	1		286
Family Oplophoridae			
Oplophoridae	1	RBCM	
Acanthinephyra curtirostris Wood-Mason, 1891	2		103, 311
Hymenodora frontalis Rathbun, 1902	16	CMN, RBCM	294, 311
Hymenodora glacialis (Buchholz, 1874)	1		104
Notostomus japonicus Bate, 1888	8	USNM	290, 311
Systellaspis sp.	1	RBCM	
Systellaspis braueri (Balss, 1914)	6		103, 311
Systellaspis cristata (Faxon, 1893)	1		104
Family Pandalidae			
Pandalidae	5		99, 171
Pandalopsis sp.	2		171
Pandalopsis dispar Rathbun, 1902	7	RBCM, ROM	95, 171, 311
Pandalus sp.	6	RBCM	22, 23, 171
Pandalus borealis Kröyer, 1838	3		95
Pandalus danae Stimpson, 1857	28		18, 23, 160, 193, 275, 286, 297
Pandalus eous Makarov, 1935	1	RBCM	
Pandalus hypsinotus Brandt, 1851	2	RBCM	95
Pandalus jordani Rathbun, 1902	12	RBCM	18, 19, 95, 104, 171
Pandalus platyceros Brandt, 1851	13	RBCM	18, 22, 23, 95, 171
Pandalus stenolepis Rathbun, 1902	2	CMN, RBCM	
Pandalus tridens Rathbun, 1902	11	CMN, RBCM	294, 311
Family Pasiphaeidae			
Pasiphaeidae	1	RBCM	
Parapasiphae sulcatifrons Smith, 1884	1		103
Pasiphaea pacifica Rathbun, 1902	25	CMN, RBCM	95, 171, 294, 311
Pasiphaea tarda Kröyer, 1845	8	CMN	104, 311

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Infraorder Thalassinidea			
Family Axiidae			
Axiopsis spinulicauda (Rathbun, 1902)	6	RBCM	
Calastacus stilirostrus Faxon, 1893	1		311
Calocarides quinqueseriatus (Rathbun, 1902)	1		167
Lophaxius rathbunae Kensley, 1989	4	RBCM	168
Family Callianassidae			
Subfamily Callianassinae			
Neotrypaea californiensis (Dana, 1854)	1	RBCM	
Family Upogebiidae			
Upogebia pugettensis (Dana, 1852)	13		8, 160, 163, 286, 296
Infraorder Anomura			
Superfamily Paguroidea			
Family Diogenidae			
Diogenidae	1	RBCM	
Paguristes sp.	3		286
Paguristes turgidus (Stimpson, 1857)	31	CMN, RBCM, ROM, USNM	18, 19, 98, 163, 167
Paguristes ulreyi Schmitt, 1921	3	RBCM	167
Family Lithodidae			
Acantholithodes hispidus (Stimpson, 1860)	6	RBCM	10, 23, 163
Cryptolithodes sitchensis Brandt, 1853	11	CMN, RBCM	9, 163, 247, 275, 276
Cryptolithodes typicus Brandt, 1849	8	CMN, RBCM	10
Hapalogaster mertensii Brandt, 1850	16	CMN, RBCM	9, 163
Lithodes aequispina Benedict, 1894	3		105, 311
Lithodes couesi Benedict, 1894	14	RBCM	167, 311
Lopholithodes sp.	3	RBCM	23
Lopholithodes foraminatus (Stimpson, 1859)	5	RBCM, USNM	101, 309
Lopholithodes mandtii Brandt, 1849	7		8, 9, 10, 12, 237, 276
Oedignathus inermis (Stimpson, 1860)	7		10, 160, 163, 286
Paralithodes sp.	2	CMN, RBCM	
Paralithodes camtschaticus (Tilesius, 1815)	3	USNM	105, 163
Paralomis multispina (Benedict, 1894)	11	MCZ, RBCM, USNM	163, 294, 311
Paralomis verrilli (Benedict, 1894)	5		169, 311
Phyllolithodes papillosus Brandt, 1849	13	CMN, RBCM	8, 9, 13, 95, 160, 237, 275
Placetron wosnessenskii Schalfeew, 1892	2	USNM	163, 294
Rhinolithodes wosnessenskii Brandt, 1849	4	CMN, RBCM	
Family Paguridae			
Paguridae	12	RBCM, ROM	23, 98, 171, 311
Discorsopagurus schmitti (Stevens, 1925)	13	RBCM	8, 9, 160, 165, 271
Elassochirus cavimanus (Miers, 1879)	1	RBCM	
Elassochirus gilli (Benedict, 1892)	1	RBCM	
Elassochirus tenuimanus (Dana, 1851)	7	RBCM	18
Labidochirus splendescens (Owen, 1839)	1	RBCM	
Orthopagurus hartae McLaughlin, 1973	1	USNM	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Orthopagurus minimus (Holmes, 1900)	10	RBCM	9, 163, 167, 273
Pagurus sp.	106	CMN, RBCM, ROM	1, 16, 23, 95, 98, 160, 161, 268, 269, 276, 296, 297, 298
Pagurus aleuticus (Benedict, 1892)	1		65
Pagurus armatus (Dana, 1851)	25	RBCM, ROM, USNM	18, 19, 98
Pagurus beringanus (Benedict, 1892)	20	RBCM	160, 163, 271, 297, 298
Pagurus caurinus Hart, 1971	10	RBCM	167, 297, 298
Pagurus confragosus (Benedict, 1892)	4	RBCM	18, 19
Pagurus cornutus (Benedict, 1892)	4	RBCM	294
Pagurus dalli (Benedict, 1892)	3	RBCM	18
Pagurus granosimanus (Stimpson, 1857)	35	RBCM	160, 163, 297, 298
Pagurus hemphilli (Benedict, 1892)	19	CMN, RBCM	160, 163, 167, 220, 298
Pagurus hirsutiusculus (Dana, 1851)	77	CMN, RBCM	160, 163, 271, 275, 297, 298
Pagurus kennerlyi (Stimpson, 1864)	4	RBCM	297
Pagurus ochotensis Brandt, 1851	8	RBCM	160, 163, 297
Pagurus quaylei Hart, 1971	2	RBCM	167
Pagurus samuelis (Stimpson, 1857)	5	RBCM	160
Pagurus setosus (Benedict, 1892)	11	RBCM	163, 297, 298
Pagurus sp. 1 of Hart, 1982	1		169
Pagurus stevensae Hart, 1971	8	RBCM	163, 167
Pagurus tanneri (Benedict, 1892)	2	CMN, RBCM	
Parapagurodes sp.	1	RBCM	
Family Parapaguridae			
Parapagurus pilosimanus Smith, 1879	1		167
Parapagurus pilosimanus benedicti de Saint Laurent, 1972	3	RBCM, USNM	
Superfamily Galatheoidea			
Family Galatheidae			
Munida sp.	4	RBCM	171
Munida quadrispina Benedict, 1902	19	CMN, RBCM	8, 22, 23, 163, 167, 294
Munidopsis quadrata Faxon, 1893	4	CMN, RBCM	
Family Porcellanidae			
Porcellanidae	2	RBCM	298
Pachycheles pubescens Holmes, 1900	9	RBCM	160, 168, 297, 298
Pachycheles rudis Stimpson, 1858	9	RBCM	160, 298
Pachycheles cf. *rudis* Stimpson, 1859	1		65
Petrolisthes sp.	12		10, 65, 161, 268, 297, 298
Petrolisthes cinctipes (Randall, 1839)	53	RBCM	9, 10, 65, 160, 163, 167, 297
Petrolisthes eriomerus Stimpson, 1871	37	RBCM	10, 12, 160, 163, 164, 268, 296, 297
Infraorder Brachyura			
Family Atelecyclidae			
Telmessus sp.	6	CMN, RBCM	268
Telmessus cheiragonus (Tilesius, 1815)	24	CMN, RBCM	9, 10, 11, 13, 160, 161, 163, 247, 271, 286, 294, 297
Family Cancridae			
Cancer sp.	6	RBCM	171, 260, 268
Cancer antennarius Stimpson, 1856	5	CMN	247, 286
Cancer branneri Rathbun, 1926	20	RBCM	18, 65, 66
Cancer gracilis Dana, 1852	76	RBCM, ROM	18, 65, 66, 98, 160, 259, 269, 298

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Cancer magister Dana, 1852	34	RBCM	10, 18, 66, 99, 161, 163, 174, 260, 268, 271, 276, 286
Cancer oregonensis (Dana, 1852)	51	CMN, RBCM	10, 13, 18, 19, 65, 160, 163, 268, 271, 275, 276, 286, 299
Cancer productus Randall, 1839	91	RBCM	9, 10, 11, 13, 160, 161, 163, 247, 259, 260, 268, 271, 275, 276, 286, 297, 298
Family Grapsidae			
Hemigrapsus sp.	8	RBCM	268, 298
Hemigrapsus nudus (Dana, 1851)	83	RBCM	160, 161, 268, 269, 271, 275, 296, 297, 298
Hemigrapsus oregonensis (Dana, 1851)	79	CMN, RBCM	160, 161, 268, 271, 296, 297, 298
Family Majidae			
Chionoecetes sp.	2		17, 24
Chionoecetes angulatus Rathbun, 1925	16	RBCM, USNM	163, 311
Chionoecetes bairdi Rathbun, 1924	3	RBCM	95
Chionoecetes tanneri Rathbun, 1893	25	RBCM	167, 294, 311
Chorilia longipes Dana, 1851	20	RBCM	9, 10, 18, 23, 163, 311
Hyas lyratus Dana, 1851	6	CMN, RBCM	18
Loxorynchus sp.	1	RBCM	
Loxorynchus crispatus Stimpson, 1857	1		10
Macroregonia macrochira Sakai, 1978	1		17
Mimulus foliatus Stimpson, 1890	17	RBCM	9, 160, 163
Oregonia bifurca Rathbun, 1902	4	CMN, RBCM	168
Oregonia gracilis Dana, 1851	43	RBCM	10, 18, 23, 160, 163, 247, 268, 271, 275, 286, 297
Pugettia sp.	16	CMN, RBCM	10, 268
Pugettia gracilis Dana, 1851	57	CMN, RBCM, USNM	160, 163, 265, 268, 271, 286, 297, 298
Pugettia producta Randall, 1839	42	CMN, RBCM	10, 160, 163, 268, 271, 275, 276, 297, 298
Pugettia richi Dana, 1851	8	RBCM, ROM	98, 160, 165, 247
Scyra acutifrons Dana, 1851	24	CMN, RBCM	160, 163, 247, 268, 276, 297
Family Pinnotheridae			
Fabia subquadrata Dana, 1851	22	RBCM	12, 97, 163, 286
Pinnixa sp.	17	RBCM, ROM	10, 98, 160
Pinnixa eburna Wells, 1928	1		165
Pinnixa faba (Dana, 1851)	1	RBCM	
Pinnixa littoralis Holmes, 1894	4	RBCM	65, 163
Pinnixa occidentalis Rathbun, 1893	36	RBCM, ROM	18, 19, 98, 163
Pinnixa schmitti Rathbun, 1918	2	RBCM	297
Pinnixa tubicola Holmes, 1894	1		165
Family Xanthidae			
Lophopanopeus bellus (Stimpson, 1860)	25	RBCM	10, 160, 161, 163, 268, 271, 297, 298
Lophopanopeus bellus bellus (Stimpson, 1860)	13	RBCM	297
Lophopanopeus bellus diegensis Rathburn, 1900	18	RBCM	298

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Phylum Phoronida			
Family Phoronidae			
Phoronis sp.	3		10, 291
Phoronis ijimai Oka, 1897	1		9
Phoronopsis harmeri Pixel, 1912	1	ROM	98
Phylum Brachiopoda (Lamp Shells)			
Class Inarticulata			
Order Neotremata			
Family Craniidae			
Neocrania californica (Berry, 1921)	19	RBCM, USNM	22
Class Articulata			
Order Rhynchonellida			
Family Frieleiidae			
Frieleia sp.	1	RBCM	
Frieleia halli Dall, 1895	14	RBCM	7, 60
Family Hemithyrididae			
Hemithiris psittacea (Chemnitz, 1885)	4		60
Order Terebratulida			
Suborder Terebratulidina			
Family Terebratulidae			
Terebratulina sp.	1		60
Terebratulina crossei Davidson, 1882	4		7, 61
Terebratulina unguicula Carpenter, 1864	21	CMN, RBCM, ROM	23, 60, 98
Suborder Terebratellidina			
Family Laqueidae			
Diestothyris frontalis (Middendorff, 1849)	1		60
Laqueus californianus Koch, 1848	72	RBCM, ROM, USNM	7, 8, 17, 22, 23, 60, 98, 126, 127, 134
Terebratalia sp.	1	RBCM	
Terebratalia transversa (Sowerby, 1846)	41	CMN, RBCM, USNM	8, 9, 60, 66, 134, 160, 173, 305
Phylum Entoprocta			
Order Coloniales			
Family Barentsiidae			
Barentsia sp.	1		23
Barentsia gracilis (Sars, 1835)	1		177
?Barentsia major Hincks, 1888	1		251
Family Loxokalypodidae			
Loxokalypus socialis Emschermann, 1972	1		147

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Pedicellinidae			
Pedicellina cernua (Pallas, 1774)	1		10
Phylum Bryozoa (Moss Animals)			
Class Stenolaemata			
Order Cyclostomata			
Suborder Tubuliporina			
Family Diastoporidae			
Diaperoecia sp.	5		9, 160
Diaperoecia californica (D'orbigny, 1852)	16	CMN, RBCM, USNM	8, 193, 298
Diaperoecia major (Johnston, 1847)	1		177
Plagioecia patina (Lamarck, 1816)	5	CMN	177
Plagioecia sarniensis (Norman, 1864)	1		177
Family Oncousoeciidae			
Oncousoecia diastroporides (Norman, 1868)	1		177
Proboscina incrassata Smitt, 1866	2		177
Family Tubuliporidae			
Entalophora sp.	1		9
Entalophora deflexa (Couch, 1841)	1		251
Entalophora vancouverensis O'Donoghue, 1923	2	CMN	
Tubulipora sp.	2	CMN	23
?Tubulipora dawsoni Hincks, 1884	1		177
Tubulipora lileacea (Pallas, 1766)	1		251
Tubulipora lobulata Hassall, 1841	1		177
Tubulipora pacifica Robertson, 1910	3	CMN	297
Tubulipora tuba (Gabb & Horn, 1862)	10	CMN	177
Suborder Articulata			
Family Crisiidae			
Bicrisia edwardsiana D'orbigny, 1852	1		8
Crisia sp.	10	CMN, RBCM	160
Crisia denticulata (Lamarck, 1816)	1		177
Crisia eburnea (Linnaeus, 1758)	1		177
Crisia occidentalis Trask, 1857	2	CMN	8
Crisia pugeti Robertson, 1910	2	RBCM	8
Crisia serrulata (Gabb & Horn, 1862)	2		8
Crisidia cornuta (Linnaeus, 1758)	4		8, 177, 251
Filicrisia sp.	5	CMN	160
Filicrisia franciscana (Robertson, 1910)	4	CMN	8, 251
Filicrisia geniculata (Robertson, 1910)	1		251
Suborder Cerioporina			
Family Heteroporidae			
Heteropora sp.	1	RBCM	
Heteropora alaskensis (Borg, 1933)	1		251
Heteropora magna O'Donoghue, 1923	14		8, 9, 10, 11, 160

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Suborder Rectangulata			
Family Lichenoporidae			
Disporella hispida (Fleming, 1828)	4	CMN	177
Disporella separata Osburn, 1953	3	RBCM	9
Disporella cf. *separata* Osburn, 1953	3		9, 10
Lichenopora novaezelandiae (Busk, 1875)	3		23
Lichenopora verrucaria (Fabricius, 1780)	1		177
Class Gymnolaemata			
Order Ctenostomata			
Suborder Euctenostomata			
Family Alcyonidiidae			
Alcyonidium sp.	4	RBCM, ROM	98, 160
Alcyonidium pedunculatum Robertson, 1902	4		8, 9, 10, 18
Alcyonidium polyoum Hassall, 1841	7	RBCM	177, 297, 298
Family Arachnidiidae			
Nolella stipata Gosse, 1855	1		177
Family Buskiidae			
Buskia nitens Alder, 1857	1		177
Family Clavoporidae			
Clavopora occidentalis (Fewkes, 1889)	1		297
Family Flustrellidridae			
Flustrellidra corniculata (Smitt, 1871)	24	CMN, USNM	8, 9, 16, 66, 160
Family Vesiculariidae			
Bowerbankia gracilis Leidy, 1855	2	RBCM	8
?*Bowerbankia imbricata* (Adams, 1800)	1		177
Order Cheilostomata			
Suborder Anasca			
Family Aeteidae			
Aetea ligulata Busk, 1852	3		177
Aetea truncata (Landsborough, 1852)	1		251
Family Alderinidae			
Alderina brevispina (O'Donoghue, 1926)	1	CMN	
Callopora sp.	1	RBCM	298
Callopora armata O'Donoghue, 1926	2	RBCM	297, 298
Callopora exilis (Hincks, 1884)	1		177
Callopora horrida (Hincks, 1880)	3	CMN	177
Callopora lineata (Linnaeus, 1767)	1	CMN	
Copidozoum protectum (Hincks, 1884)	2		177
Copidozoum tenuirostre (Hincks, 1880)	2		177
Tegella arctica (d'Orbigny, 1851)	1		177
Tegella armifera (Hincks, 1880)	1	CMN	
Tegella robertsonae O'Donoghue, 1926	3	CMN	
Tegella unicornis (Flemming, 1828)	1		177
Family Beaniidae			
Beania columbiana O'Donoghue, 1923	1		251

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Bicellariellidae			
Bugula avicularia (Linnaeus, 1758)	2		177
Bugula californica Robertson, 1905	7	RBCM	8, 160
Bugula harmsworthi Waters, 1900	1	RBCM	
Bugula longirostrata Robertson, 1905	1		251
Bugula pacifica Robertson, 1905	8	CMN, USNM	8, 10, 66, 251
Bugula pugeti Robertson, 1905	1	RBCM	
Corynoporella sp.	1		23
?*Corynoporella spinosa* Robertson, 1905	1		23
Dendrobeania sp.	3	CMN	
Dendrobeania curvirostrata (Robertson, 1905)	1	RBCM	
Dendrobeania lichenoides (Robertson, 1900)	13	CMN	8, 160
Dendrobeania murrayana (Johnston, 1847)	8	CMN, RBCM	8, 177, 251
Family Cellariidae			
Cellaria sp.	4		9, 12
Cellaria diffusa Robertson, 1905	1		20
Cellaria mandibulata Hincks, 1882	4		8, 177, 251
Family Chapperiellidae			
Chapperia patula (Hincks, 1881)	4		8, 177
Family Cribrilinidae			
Cribrilina annulata (Fabricius, 1780)	12	CMN, RBCM	298
Cribrilaria radiata (Moll, 1803)	3		177, 297
Lyrula hippocrepis (Hincks, 1882)	3	CMN	177
Puellina setosa (Waters, 1899)	2	RBCM	298
Reginella furcata (Hincks, 1882)	3		177, 297
Reginella nitida Osburn, 1950	2	CMN	
Family Flustridae			
Flustra sp.	1		9
Terminoflustra membranaceotruncata (Smitt, 1867)	1		177
Family Hincksinidae			
Cauloramphus sp.	1	RBCM	297
Cauloramphus brunea Canu & Bassler, 1930	1		298
Cauloramphus echinus Hincks, 1882	4	RBCM	177, 297, 298
Cauloramphus spiniferum (Johnston, 1832)	14	CAS, CMN, RBCM	297, 298
Cauloramphus variegatum (Hincks, 1884)	1		177
Ellisina levata (Hincks, 1882)	2		177
Hincksina alba (O'Donoghue, 1923)	1		8
Hincksina minuscula (Hincks, 1884)	2	CMN	177
Hincksina nigrans (Hincks, 1882)	1		177
Hincksina pallida (Hincks, 1884)	2	RBCM	177
Hincksina velata (Hincks, 1881)	2	CMN	177
Family Membraniporidae			
Desmacystis sandalia (Robertson, 1900)	2	USNM	
Membranipora sp.	3		297
Membranipora membranacea (Linnaeus, 1767)	7		177, 193, 275
Membranipora serrilamella Osburn, 1950	1		177
Membranipora villosa Hincks, 1880	2	USNM	252

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Family Microporidae			
Micropora sp.	2	RBCM	297
Micropora coriacea Soule, 1959	1	RBCM	297
Microporina borealis (Busk, 1855)	6	RBCM	8, 177
Mollia rosselii (Audouin, 1826)	1		177
Family Scrupariidae			
Brettia ciliata (Linnaeus, 1758)	1		251
Eucratea loricata (Ortmann, 1890)	4	CMN	177, 251
Family Scrupocellariidae			
Scrupocellariidae	6		160
Caberea ellisi (Fleming, 1814)	2		23, 177
Scrupocellaria varians Hincks, 1882	1		177
Scrupocellaria californica Trask, 1857	3		8, 177
Tricellaria erecta (Robertson, 1900)	1		8
Tricellaria gracilis (Smit, 1867)	3		177, 251
Tricellaria occidentalis (Trask, 1857)	5	CMN	177, 251
Tricellaria ternata (Ellis & Solander, 1786)	6	CMN	177
Suborder Ascophora			
Family Celleporidae			
Celleporaria brunnea (Hincks, 1884)	2		9, 177
Costazia sp.	3	RBCM	
Costazia costazi Audouin, 1826	5	CMN, RBCM	251, 298
Costazia robertsoniae Canu & Bassler, 1923	2	CMN	
Costazia surcularis (Packard, 1863)	2		177
Lagenipora sp.	1		8
Lagenipora lepralioides (Norman, 1868)	2	CMN	
Lagenipora spinulosa Hincks, 1883	4	CMN	177
Family Cheiloporinidae			
Cheilopora praelonga Hincks, 1883	9	CMN, RBCM	177, 298
Cheilopora praelucida (Hincks, 1884)	1		177
**Cryptosula pallasiana* (Moll, 1803)	3	CMN	
Family Escharellidae			
Escharella major (Hincks, 1884)	1		177
Family Eurystomellidae			
Eurystomella bilabiata (Hincks, 1884)	10		8, 10, 13, 160, 177
Family Hippoporinidae			
Hippoporella nitescens (Hincks, 1884)	3		177
Family Hippothoidae			
Celleporella hyalina (Linnaeus, 1767)	19	CMN, RBCM	8, 177
Hippothoa distans MacGillivray, 1869	2		177
Hippothoa divaricata Gordon, 1984	2	CMN	
Hippothoa expansa Dawson, 1859	1		177
Trypostega claviculata (Hincks, 1884)	2		177
Family Microporellidae			
Microporellidae	1	RBCM	
Fenestrulina malusii (Audouin, 1826)	11	CMN	8, 177, 298
Fenestrulina malusii umbonata O'Donoghue, 1926	3	RBCM	298

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Microporella sp.	1	RBCM	298
Microporella borealis Suwa & Mawatari, 1998	1		8
Microporella californica (Busk, 1856)	3	RBCM	177, 298
Microporella ciliata (Pallas, 1766)	12	CMN	
Microporella coriacea (Esper, 1791)	4	RBCM	8, 177, 297
Microporella umbonata (Hincks, 1884)	1		177
Microporella vibraculifera (Hincks, 1884)	2		8, 177
Family Myriozoidae			
Myriozoum sp.	4	RBCM	22
Myriozoum coarctatum (Sars, 1850)	2		177
Myriozoum tenue O'Donoghue, 1923	2		8
Family Reteporidae			
Phidolopora sp.	2	RBCM	
Phidolopora labiata (Gabb & Horn, 1862)	5		8, 9, 10, 177
Rhynchozoon rostratum (Busk, 1856)	4	CMN, USNM	177
Schizotheca fissurella Hincks, 1884	2		177
Family Schizoporellidae			
Arthropoma cecilii (Audouin, 1826)	1		177
Dakaria dawsoni (Hincks, 1883)	1		177
Dakaria pristina (Hincks, 1883)	1		177
Hippodiplosia sp.	1	CMN	
Hippodiplosia insculpta Hincks, 1882	23	CMN, RBCM, USNM	8, 10, 13, 160, 177, 298
Hippomonavella longirostrata (Hincks, 1883)	1		177
Schizomavella auriculata (Hassall, 1842)	1		177
Schizoporella cornuta (Gabb & Horn, 1862)	5	CMN	10, 177
Schizoporella crassilabris Hincks, 1884	4	CMN	177
?*Schizoporella maculosa* Hincks, 1884	1		177
**Schizoporella unicornis* (Johnston, 1874)	1		160
Family Smittinidae			
Escharella ventricosa (Hassall, 1842)	3	CMN	177
Mucronella sp.	1	CMN	
Parasmittina sp.	2	CMN	
Parasmittina collifera (Robertson, 1908)	2	CMN	
Parasmittina trispinosa (Johnston, 1838)	5	CMN	177
Porella sp.	1	CMN	
Porella acutirostris Smitt, 1867	3	CMN	177
?*Porella argentea* Hincks, 1884	1		177
Porella concinna (Busk, 1854)	2	CMN	177
Porella porifera (Hincks, 1884)	2	CMN	177
Rhamphostomella sp.	1	CMN	
Rhamphostomella cellata (O'Donoghue, 1923)	2	CMN	
Rhamphostomella costata (Lorenz, 1886)	2	RBCM	298
Rhamphostomella plicata (Smitt, 1868)	2		177
Smittina spathulifera (Hincks, 1884)	1		177
Family Stomachetosellidae			
Pachystegis brunnea (Hincks, 1889)	1		177
Stomachetosella cruenta (Norman, 1864)	1		177

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Stomachetosella sinuosa (Busk, 1860)	1		177
Family Umbonulidae			
Umbonula arctica (Sars, 1851)	2	CMN	177
Phylum Echinodermata (Sea Stars, Sea Urchins, Sea Cucumbers, Sea Lillies, Brittlestars)			
Class Crinoidea			
Order Hyocrinida			
Family Hyocrinidae			
Hyocrinidae	1		17
Ptilocrinus pinnatus Clark, 1907	1	USNM	33, 109
Order Comatulida			
Family Antedonidae			
Antedonidae	1		17
Florometra asperrima (Clark, 1907)	2	CMN, RBCM	
Florometra serratissima (Clark, 1907)	9	RBCM	8, 22, 23
Psathyrometra fragilis Clark, 1908	1	USNM	
Psathyrometra profundorum Clark, 1908	1	USNM	
Class Asteroidea			
Order Paxillosida			
Family Astropectinidae			
Dipsacaster sp.	2	RBCM, ROM	
Dipsacaster anoplus Fisher, 1910	8	CMN, RBCM	206, 207
Dipsacaster borealis Fisher, 1910	1		206
Leptychaster anomalus Fisher, 1906	1	RBCM	
Leptychaster arcticus (Sars, 1851)	3	RBCM	206
Leptychaster pacificus Fisher, 1906	6	CMN, RBCM	23
Psilaster pectinatus (Fisher, 1905)	1		206
Family Ctenodiscidae			
Ctenodiscus crispatus (Retzius, 1805)	3	USNM	311
Family Luidiidae			
Luidia sp.	17	CMN	259, 260
Luidia foliolata Grube, 1866	18	CMN, RBCM	18, 22, 311
Family Porcellanasteridae			
Eremicaster pacificus (Ludwig, 1905)	1	RBCM	
Order Notomyotida			
Family Benthopectinidae			
Benthopecten claviger Fisher, 1910	1		206
Cheiraster dawsoni (Verrill, 1880)	6	RBCM, ROM	206
Nearchaster sp.	6	RBCM	
Nearchaster aciculosus (Fisher, 1910)	7	CMN	206
Nearchaster variabilis (Fisher, 1910)	5	RBCM	206, 212

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Pectinaster agassizi evoplus (Fisher, 1910)	2	RBCM	206, 207
Order Valvatida			
Family Asterinidae			
Asterina miniata (Brandt, 1835)	72	CMN, RBCM, YPM	1, 8, 9, 10, 11, 12, 160, 161, 193, 206, 268, 269, 275, 276, 297, 298, 305
Family Asteropseidae			
Dermasterias sp.	16		259, 260
Dermasterias imbricata (Grube, 1857)	106	CAS, CMN, RBCM	10, 13, 16, 160, 161, 206, 238, 268, 269, 271, 275, 276, 297, 298, 305
Family Goniasteridae			
Ceramaster sp.	1		260
***Ceramaster arcticus** (Verrill, 1909)*	2	CMN	207
Ceramaster patagonicus (Sladen, 1889)	26	CMN, RBCM	22, 23, 206, 207
Cryptopeltaster lepidonotus Fisher, 1904	2	RBCM	206, 207
Gephyreaster swifti (Fisher, 1905)	8	RBCM	22, 206
Hippasteria sp.	4		259, 260
Hippasteria californica Fisher, 1904	11	RBCM	206, 207
Hippasteria leiopelta unk	1	CMN	
Hippasteria spinosa (Verrill, 1909)	33	CMN, RBCM	22, 206, 311
Mediaster sp.	14		22, 259, 260
Mediaster aequalis Stimpson, 1857	61	CMN, RBCM, YPM	8, 9, 10, 16, 18, 20, 22, 206, 276, 305, 311
Pentagonaster granularis (Müller,)	2	CMN	
Pseudarchaster sp.	2	RBCM	
Pseudarchaster alascensis Fisher, 1905	12	CAS, CMN, RBCM	23, 206
Pseudarchaster dissonus Fisher, 1910	1		206
Pseudarchaster parelii (Duben & Koren, 1846)	1	ROM	
Family Poraniidae			
Poraniopsis sp.	1	CMN	
Poraniopsis inflatus inflatus (Fisher, 1906)	9	RBCM	206, 207, 212
Order Velatida			
Family Pterasteridae			
Diplopteraster multipes (Sars, 1865)	3	CMN, RBCM	206
Hymenaster sp.	1	RBCM	
Hymenaster quadrispinosus Fisher, 1905	3	CMN	206
Pteraster sp.	4		259, 260
Pteraster militaris (Müller, 1776)	8	CMN	23
Pteraster tesselatus Ives, 1888	17	CMN, RBCM	22, 160, 206
Family Solasteridae			
Solasteridae	2	RBCM, ROM	98
Crossaster sp.	20	CMN	259, 260
Crossaster papposus (Linnaeus, 1767)	47	CMN, RBCM	8, 9, 10, 13, 20, 22, 23, 160, 206, 275, 297, 298
Lophaster sp.	1	RBCM	
Lophaster furcifer vexator Fisher, 1910	2	CMN	
Lophaster furcilliger Fisher, 1905	10	CAS, CMN, RBCM, USNM	206
Solaster sp.	38	CMN, YPM	22, 259, 260, 268, 276

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Solaster borealis Fisher, 1906	8	RBCM, USNM	206
Solaster dawsoni Verrill, 1880	38	CAS, CMN, RBCM	10, 13, 16, 22, 160, 206, 276, 305
Solaster endeca (Linnaeus, 1771)	20	CMN, RBCM	206, 311
Solaster paxillatus Sladen, 1889	4	RBCM	22, 207
Solaster stimpsoni Verrill, 1880	51	CMN, RBCM, YPM	9, 12, 13, 22, 160, 206, 275, 276
Order Spinulosida			
Family Echinasteridae			
Henricia sp.	17	CMN, RBCM	8, 9, 22, 259, 260, 311
Henricia aspera aspera Fisher, 1906	9	CMN, RBCM, USNM	206, 207
Henricia asthenactis Fisher, 1910	2		206, 207
Henricia leviuscula (Stimpson, 1857)	109	CMN, RBCM, YPM	8, 10, 12, 13, 16, 22, 95, 160, 193, 206, 268, 271, 275, 276, 305
Henricia leviuscula annectens Fisher, 1910	12	RBCM	206, 207
Henricia leviuscula dyscrita Fisher, 1911	2	RBCM	206
Henricia leviuscula inequalis (Stimpson, 1857)	16	CMN, YPM	
Henricia leviuscula multispina Fisher, 1910	1	RBCM	
Henricia sanguinolenta (Müller, 1776)	27	CMN, RBCM, ROM	22, 23, 98, 206
Order Forcipulatida			
Family Asteriidae			
Evasterias troschelii (Stimpson, 1862)	73	CAS, CMN, RBCM, YPM	9, 10, 13, 14, 160, 161, 193, 206, 259, 260, 268, 269, 275, 276, 297
Leptasterias sp.	6	RBCM, YPM	305
Leptasterias hexactis (Stimpson, 1862)	88	CMN, RBCM, USNM, YPM	10, 12, 16, 160, 206, 268, 271, 275, 276, 296, 297, 305
Orthasterias sp.	14		259, 260
Orthasterias koehleri (de Loriol, 1897)	82	CMN, RBCM	8, 10, 12, 16, 20, 22, 160, 206, 275, 276, 298
Pisaster sp.	117	RBCM	259, 268, 269
Pisaster brevispinus (Stimpson, 1857)	37	RBCM	9, 10, 11, 16, 18, 19, 22, 160, 193, 212, 260, 271, 275, 276, 297
Pisaster ochraceus (Brandt, 1835)	102	CAS, CMN, RBCM	8, 9, 10, 16, 160, 161, 238, 259, 268, 271, 275, 276, 297, 305
Pisaster ochraceus annectens (Brandt, 1835)	1	CMN	
Pycnopodia sp.	133		259, 260, 268
Pycnopodia helianthoides (Brandt, 1835)	133	CMN, RBCM	9, 10, 12, 13, 16, 18, 19, 22, 160, 161, 193, 206, 238, 268, 269, 271, 275, 276, 297, 298, 305
Stylasterias sp.	1	RBCM	
Stylasterias forreri (de Loriol, 1887)	35	RBCM	9, 10, 12, 16, 22, 23, 206, 276
Family Pedicellasteridae			
Ampheraster marianus (Ludwig, 1905)	2		206, 207
Pedicellaster magister Fisher, 1923	2		206
Tarsaster alaskensis Fisher, 1928	2		206, 207
Family Zoroasteridae			
Myxoderma platyacanthum (Clark, 1913)	1	CAS	
Zoroaster sp.	1	RBCM	
Zoroaster evermanii mordax Fisher, 1919	3	RBCM	206, 207
Zoroaster evermanni Fisher, 1904	7	RBCM	206, 207

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Order Brisingida			
Family Brisingidae			
Astrolirus panamensis (Ludwig, 1905)	1	RBCM	
Craterobrisinga synaptoma (Fisher, 1917)	1	USNM	207
Freyella microplax (Fisher, 1917)	2	CAS, USNM	
Freyellaster fecundus (Fisher, 1905)	2	RBCM	206, 207
Class Ophiuroidea			
Order Phrynophiurida			
Suborder Euryalina			
Family Asteronychidae			
Asteronyx loveni Müller & Mortensen, 1899	12	RBCM, USNM	24, 26, 110
Family Gorgonocephalidae			
Gorgonocephalus sp.	3	CMN	259
Gorgonocephalus eucnemis Müller & Troschel, 1842	14	RBCM	18, 19, 24, 26, 260
Suborder Ophiomyxina			
Family Ophiomyxidae			
Ophioscolex corynetes (Clark, 1911)	1		26
Order Ophiurida			
Suborder Laemophiurina			
Family Ophiacanthidae			
Ophiacanthidae	2		17, 23
Ophiacantha bathybia Clark, 1911	2	USNM	110
Ophiacantha rhachophora Clark, 1911	8	RBCM	26
Ophiolimna bairdi (Lyman, 1883)	3	RBCM	26
Ophiopthalmus sp.	4	CMN	26
Ophiopthalmus cataleimmoidus (Clark, 1911)	7	CMN	7, 26
Ophiopthalmus diplasia (Clark, 1911)	1		26
Ophiopthalmus eurypoma Clark, 1911	1	USNM	110
Ophiopthalmus normani (Lyman, 1879)	6	USNM	7, 26
Suborder Gnathophiurina			
Family Amphiuridae			
Amphiuridae	9	ROM	23, 98
Amphilepas patens Lyman, 1879	2	USNM	26, 110
Amphiodia sp.	2		9, 268
Amphiodia occidentalis (Lyman, 1960)	15	CMN, RBCM	9, 26, 160, 271, 297
Amphiodia periercta Clark, 1911	19	CMN, RBCM, ROM	26, 98, 297
Amphiodia urtica (Lyman, 1860)	14	CMN, RBCM, ROM	26, 98, 297, 305
Amphioplus sp.	2	ROM	98
Amphioplus macraspis (Clark, 1911)	8	RBCM, ROM	26, 98, 298
Amphioplus strongyloplax (Clark, 1911)	17	RBCM, ROM	26, 98
Amphipholis pugetana (Lyman, 1860)	18	CAS, RBCM, ROM	8, 9, 26, 98, 160, 297
Amphipholis squamata (Delle Chiaje, 1829)	14	RBCM, ROM	26, 65, 98, 297
Amphiura sp.	1	RBCM	
Amphiura polyacantha Lütken & Mortensen, 1899	1		26
Family Ophiactidae			
Ophiopholis sp.	2		268

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Ophiopholis aculeata (Linnaeus, 1767)	55	CAS, RBCM	8, 9, 10, 12, 16, 20, 22, 153, 160, 161, 275, 276, 297
Ophiopholis aculeata japonica (Lyman, 1879)	14	RBCM	26, 298
Ophiopholis aculeata kennerlyi (Lyman, 1860)	15		8, 26, 305
Ophiopholis aculeata typica of Austin & Haylock, 1973	9		26
Ophiopholis bakeri Mcclendon, 1909	8	USNM	23, 26, 110
Ophiopholis longispina Clark, 1911	1		26
Suborder Chilophiurina			
Family Ophiodermatidae			
Ophioderma panamense Lütken, 1859	1	CMN	
Family Ophiuridae			
Ophiuridae	1		17
Amphiophiura ponderosa (Lyman, 1878)	14	CMN, RBCM, USNM	26
Ophiocten hastatum Lyman, 1878	4	USNM	26, 110
Ophiomusium glabrum Lütken & Mortensen, 1899	3		26
Ophiosphalma jolliense (McClendon, 1909)	1		26
Ophiomusium lymani Wyville Thompson, 1873	6	RBCM, USNM	26, 110
Ophiura sp.	26	ROM	22, 23, 26, 98
Ophiura bathybia Clark, 1911	1	USNM	110
Ophiura cryptolepas Clark, 1911	1		26
Ophiura flagellata (Lyman, 1878)	1	USNM	
Ophiura leptoctenia Clark, 1911	18	RBCM, USNM	7, 23, 26, 110
Ophiura luetkeni Lyman, 1860	82	CMN, RBCM, ROM	8, 9, 10, 18, 19, 22, 23, 26, 98, 160, 305
Ophiura sarsi Lütken, 1855	62	CMN, RBCM, ROM	8, 18, 19, 23, 26, 98
Stegophiura superba Lütken & Mortensen, 1899	5	CMN, RBCM, USNM	26, 110
Class Echinoidea			
Subclass Euechinoidea			
Order Echinothuroidea			
Family Echinothuriidae			
?*Sperosoma biseriatum* Döderlein, 1901	1		24
?*Sperosoma giganteum* Agassiz & Clark, 1907	1		24
Order Echinoida			
Family Strongylocentrotidae			
Allocentrotus fragilis (Jackson, 1912)	23	CMN, RBCM, ROM, USNM	18, 19, 22, 23, 24, 311
Strongylocentrotus sp.	8	RBCM	259, 260
Strongylocentrotus droebachiensis (Müller, 1776)	76	CAS, CMN, RBCM, USNM	9, 10, 12, 23, 65, 160, 161, 174, 193, 259, 268, 271, 275, 276, 297, 298, 305
Strongylocentrotus franciscanus (Agassiz, 1863)	156		1, 8, 9, 10, 11, 12, 13, 14, 16, 20, 95, 160, 161, 193, 238, 260, 268, 271, 275, 276, 297, 298, 306
Strongylocentrotus pallidus (Sars, 1871)	6	RBCM	13, 22
Strongylocentrotus purpuratus (Stimpson, 1857)	42	CMN, RBCM, USNM	9, 10, 12, 14, 160, 238, 268, 275, 276, 297, 305

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Order Clypeasteroida			
Suborder Scutellina			
Family Dendrasteridae			
Dendraster excentricus (Eschscholtz, 1831)	85	CAS, CMN, RBCM, ROM	9, 13, 18, 98, 160, 259, 260, 305
Order Holasteroida			
Family Pourtalesiidae			
Echinocrepis rostrata Mironov, 1973	1		241
Pourtalesia sp.	1		242
Spatagocystis sp.	1		242
Order Spatangoida			
Suborder Hemiasterina			
Family Schizasteridae			
Brisaster sp.	3		95
?Brisaster fragilis Düben & Koren,	1	RBCM	
Brisaster latifrons (Agassiz, 1898)	13	CMN, RBCM	24
Class Holothuroidea			
Order Dendrochirotida			
Family Cucumariidae			
Cucumariidae	5	RBCM	208
Cucumaria sp.	11	CMN, RBCM	268, 276
Cucumaria curata Cowles, 1907	4		10, 268
Cucumaria frondosa japonica (Gunnerus, 1767)	4	CMN, RBCM	208
Cucumaria miniata (Brandt, 1835)	79	CMN, RBCM	9, 10, 11, 12, 13, 22, 160, 161, 199, 208, 237, 238, 271, 275, 276, 297, 298
Cucumaria pallida Fischer von Waldheim, 1820	5	RBCM	
Cucumaria piperata (Stimpson, 1864)	24	RBCM	9, 111, 160, 298
Cucumaria pseudocurata Deichmann, 1938	31	RBCM	8, 12, 16, 160, 208, 297
Cucumaria vegae Théel, 1886	3	CMN, RBCM	
Ekmania diomedeae (Ohshima, 1915)	1	RBCM	
Pseudocnus lubricus (Clark, 1901)	22	CMN, RBCM	10, 160, 208, 210, 211, 298
Sphaerothuria bitentaculata (Ludwig, 1893)	1	RBCM	
Thyonidium pellucidum (Fleming, 1954)	1		208
Family Phyllophoridae			
Pentamera sp.	14	RBCM, ROM	9, 22, 98
Pentamera lissoplaca (Clarke, 1924)	7	CMN, RBCM	208
Pentamera pediparva Lambert, 1987	5	RBCM	
Pentamera populifera (Stimpson, 1864)	6	RBCM	
Pentamera pseudocalcigera Deichmann, 1938	7	CMN, RBCM	18, 19, 208
Pentamera pseudopopulifera Deichmann, 1938	1	RBCM	
Pentamera rigida Lambert, 1987	11	RBCM	
Pentamera trachyplaca *(Clarke, 1924)*	2	RBCM	208
Thyone benti (Deichmann, 1937)	19	RBCM, ROM	98, 208
Family Psolidae			
Psolidium bidiscum Lambert, 1996	8	RBCM	

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Psolus sp.	8	CMN, RBCM	208
Psolus chitinoides Clark, 1901	9	RBCM	8, 9, 208, 276, 297, 298
Psolus squamatus (Koren, 1884)	12	RBCM	23, 208, 311
Family Sclerodactylidae			
Eupentacta sp.	5	RBCM	22, 98, 268
Eupentacta pseudoquinquesemita Deichmann, 1938	7	CMN, RBCM	9, 160, 297, 298
Eupentacta quinquesemita (Selenka, 1867)	23	CMN, RBCM	9, 10, 160, 208, 268, 271, 297, 298
Order Aspidochirotida			
Family Stichopodidae			
Parastichopus sp.	15	CMN, RBCM	208, 209
Parastichopus californicus (Stimpson, 1857)	88	CMN, RBCM	1, 8, 9, 10, 11, 13, 16, 20, 22, 65, 160, 161, 193, 208, 268, 275, 276, 297, 298
Parastichopus leucothele Lambert, 1986	14	CAS, CMN, RBCM, USNM	22, 23, 209, 293, 297
Stichopus sp.	20	RBCM	259, 260
Stichopus sitchaensis (Brandt, 1835)	1		293
Family Synallactidae			
Capheira mollis Ohshima, 1915	1	RBCM	208
Pseudostichopus sp.	2	RBCM	
Pseudostichopus mollis Théel, 1886	26	CMN, RBCM	208
Synallactes challengeri (Théel, 1886)	10	RBCM	208, 311
Order Elasipodida			
Family Elpidiidae			
Amperima naresi (Théel, 1882)	1	RBCM	208
Scotoplanes globosa (Théel, 1879)	2	RBCM	208
Family Laetmogonidae			
Pannychia moseleyi Théel, 1882	3	RBCM	208
Order Apodida			
Family Chiridotidae			
Chiridota sp.	6	RBCM	
Chiridota albatrossi Edwards, 1907	3	CMN, ROM, USNM	98, 146
Chiridota laevis (Fabricus, 1780)	1		98
Chiridota nanaimensis Heding, 1928	3	ROM	98
Family Synaptidae			
Leptosynapta sp.	10	RBCM	8, 10, 16, 268, 271
Leptosynapta clarki Heding, 1928	19	CMN, RBCM, ROM	65, 98, 160, 297, 298
Leptosynapta galliennii (Herapath, 1865)	1	RBCM	
Leptosynapta transgressor Heding, 1928	3	ROM	98, 160
Order Molpadiida			
Family Caudinidae			
Paracaudina sp.	1	CMN	
Paracaudina chilensis (Müller, 1850)	4	RBCM	208
Family Molpadiidae			
Molpadia sp.	1	RBCM	
Molpadia intermedia (Ludwig, 1894)	12	CMN, RBCM	98, 160, 208, 311

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Phylum Urochordata (Tunciates, Salps)			
Class Ascidiacea			
Order Enterogona			
Suborder Aplousobranchia			
Family Clavelinidae			
Clavelina huntsmani Van Name, 1931	13	RBCM	9, 10, 12, 160, 161
Cystodytes lobatus (Ritter, 1900)	2		9, 160
Distaplia sp.	1	RBCM	
Distaplia occidentalis Bancroft, 1899	3		160, 271
Eudistoma sp.	1		9
Eudistoma psammion (Ritter & Forsyth, 1917)	5		160
Eudistoma ritteri (Van Name, 1945)	1		160
Pycnoclavella stanleyi Berrill & Abbott, 1949	1		12
Family Didemnidae			
Didemnidae	12	RBCM	160
Didemnum sp.	9		8, 9, 10, 11, 12, 268
Didemnum albidum (Hartmeter, 1903)	1	RBCM	297
Diplosoma macdonaldi Herdman, 1886	1		297
Trididemnum sp.	1		22
Family Polyclinidae			
Aplidium sp.	2		98, 268
Aplidium solidum (Ritter & Forsyth, 1917)	13		160, 271
Euherdmania pulchra (Oka, 1933)	8		160, 271
Synoicum parfustis (Ritter & Forsyth, 1917)	12		160
Synoicum rubrum (Abbott & Trason, 1968)	7		9, 10, 11, 12, 160
Order Phlebobranchia			
Family Agnesiidae			
Agnesia septentrionalis Huntsman, 1912	1	ROM	107, 186
Family Ascidiidae			
Ascidia sp.	12	RBCM	23
Ascidia callosa Stimpson, 1852	5	RBCM	10, 160, 297
Ascidia ceratodes (Huntsman, 1912)	1		22
Ascidia cf. *ceratodes* (Huntsman, 1912)	1		22
Ascidia paratropa (Huntsman, 1912)	1		276
Ascidia cf. *paratropa* (Huntsman, 1912)	1		65
Family Cionidae			
•*Ciona intestinalis* (Stimpson, 1852)	1	RBCM	
Family Corellidae			
Chelyosoma sp.	4	CMN	8, 276
Chelyosoma columbianum Huntsman, 1912	29	RBCM	98, 297
Chelyosoma productum Stimpson, 1864	13	RBCM, ROM	9, 10, 160, 186
Corella sp.	1		22
Corella willmeriana Herdman, 1898	5	RBCM, ROM	23, 186
Family Perophoridae			
Perophora annectens Ritter, 1893	23	RBCM	8, 10, 16, 160, 298

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Order Stolidobranchia			
Family Molgulidae			
Mogula pugetiensis Herdman, 1898	2	ROM	107, 186
Molgula sp.	2	RBCM	8
Molgula occulta Forbes, 1848	1	RBCM	
Family Pyuridae			
Bathypera feminalba Young & Vazquez, 1995	2		22
Boltenia echinata (Linnaeus, 1767)	2		9
Boltenia villosa (Stimpson, 1864)	13	CMN, RBCM	12, 160, 193, 276, 297
Halocynthia aurantium (Pallas, 1787)	2		160
Halocynthia igaboja Oka, 1906	17	CMN, RBCM	9, 20, 22, 160, 297
Pyura sp.	1	RBCM	
Pyura haustor (Stimpson, 1864)	22	RBCM, USNM	10, 11, 13, 23, 160, 271, 298
Pyura mirabilis (Von Drasche, 1884)	3	RBCM	12, 298
Family Styelidae			
Styelidae	1	RBCM	
Cnemidocarpa finmarkiensis Kiaer, 1893	16	RBCM	9, 160, 275, 276, 298
Metandrocarpa dura (Ritter, 1896)	11		8, 9, 10, 160
Metandrocarpa taylori Huntsman, 1912	7		9, 13, 160
**Pelonaia corrugata* Goodsir & Forbes, 1848	1		186
Styela sp.	3	RBCM	160
Styela coriacea Ritter, 1913	7	RBCM	297, 298
Styela gibbsii (Stimpson, 1864)	5	RBCM	19
Styela montereyensis (Dall, 1872)	2		276
Class Thaliacea			
Order Salpida			
Family Salpidae			
Salpidae	2	RBCM	
Salpa aspera Chamisso, 1819	1		15
Salpa fusiformis Cuvier, 1804	1		56
Salpa maxima Forskaal, 1775	1	RBCM	
Class Larvacea			
Family Oikopleuridae			
Oikopleura sp.	1		65
Oikopleura dioica Fol, 1872	5		229, 291

Taxon	Observations Recorded	Museum Collections	References in Appendix E
Phylum Chaetognatha (Arrow Worms)			
Class Sagittoidea			
Order Phragmophora			
Family Eukrohniidae			
Eukrohnia hamata (Mobius, 1875)	15	RBCM	156, 216
Order Aphragmophora			
Family Sagittidae			
Mesosagitta decipens (Fowler, 1905)	8	RBCM	142, 216, 257
Parasagitta elegans (Verrill, 1873)	39	RBCM	142, 156, 216, 257, 291
Pseudosagitta scrippsae (Alvarino 1962)	5	RBCM	216
Sagitta sp.	9	RBCM	258
Sagitta zetesios (Fowler, 1905)	1	RBCM	
Phylum Hemichordata (Acorn Worms)			
Class Enteropneusta			
Family Harrimaniidae			
Saccoglossus sp.	2	RBCM	296

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Appendix F

Marine Invertebrate Species for which the Haida Gwaii Region is their Type Locality

Some marine invertebrate species were first described (and named) for science from material collected in the Haida Gwaii region. These species are listed here according to phylum. For a subset of these species (see Table 8 in the text), the Haida Gwaii region remains the only region from which these species are known. We do not, however, claim endemic status for any marine invertebrate species for the Haida Gwaii region at this time.

There are very specific rules for naming animals in the *International Code of Zoological Nomenclature* (Jeffrey 1973). The specimens from which a species is described are collectively called "*type*" specimens. Type specimens are the anchour point for the species' name. Sometimes, a new species is described from just one specimen. Often, however, a species is described from a number of specimens collected over the same time period from one or more locations. As well, the type material may be dispersed among institutions after being used for describing the species. Accordingly, there are various categories of type material described in Jeffrey (1973).

Porifera
Craniella villosa Lambe, 1893

Cnidaria
Pandea rubra Bigelow, 1913
Paraphelliactis pabista Dunn, 1982
Paulinum lineatum Brinckman-Voss & Arai, 1998

Nemertea
Pelagonemertes brinckmanni Coe, 1926

Annelida
Bathydrilus litoreus Baker, 1983
Nootkadrilus hamatus Baker, 1982
Spio butleri Berkeley & Berkeley, 1954
Sthenelais berkelyi Pettibone, 1971

Sipuncula
Nehasoma wodjanizkii (Murina, 1973)

Pogonophora
Heptabrachia canadensis Ivanov, 1962
Lamellisabella coronata Southward, 1969

Mollusca
Aforia crebristriata (Dall, 1908)
Anidolyta spongotheras (Bertsch, 1980)
Benthoctopus robustus Voss & Pearcy, 1990

Calliotropis carlotta (Dall, 1902)
Cetomya malespinae (Dall, 1916)
Cocculina cowani McLean, 1987
Colus sapius Dall, 1919
Craniopsis decorata (Cowan & Mclean, 1968)
Cuspidaria apodema Dall, 1916
Cuspidaria cowani Bernard, 1967
Cyclopecten carlottensis Bernard, 1968
Dallicordia alaskana (Dall, 1895)
Diaphorodoris lirulatocauda Millen, 1985
Fissurisepta pacifica Cowan, 1969
Gastropteron pacificum Bergh, 1893
Ischnochiton abyssicola Smith & Cowan, 1966
Katadesmia gibbsi (Dall, 1897)
Kelliella galatheae Knudsen, 1970
Lepidopleurus mesogonus Dall, 1902
Macoma carlottensis Whiteaves, 1880
Mangelia carlottae Dall, 1919
Mohnia freilei Dall, 1891
Morisonella pacifica (Dall, 1908)
Nucula carlottensis Dall, 1897
Nuculana extenulata (Dall, 1897)
Odostomia cassandra Bartsch, 1912
Odostomia cypria Dall & Bartsch, 1912
Odostomia oregonensis Dall & Bartsch, 1907
Odostomia pharcida Dall & Bartsch, 1907
Odostomia skidegatensis Bartsch, 1912
Okenia vancouverensis (O'Donoghue, 1921)
Rissoina newcombei Dall, 1897
Sabinella ptilocrinicola (Bartsch, 1907)
Solariella peramabilis Carpenter, 1864
Spiromoelleria quadrae (Dall, 1897)
Tricolia lurida Dall, 1897

Arthropoda
Aetideus divergens Bradford, 1971
Americhelidium rectipalmum (Mills, 1962)
Atylus borealis Bousfield & Kendall, 1994
Byblis mulleni Dickinson, 1983
Caprella pustulata Laubitz, 1970
Caprella rudiuscula Laubitz, 1970
Caprella ungulina Mayer, 1903
Diastylopsis dawsoni Smith, 1879
Eualus biunguis (Rathbun, 1902)
Euchaetomeropsis pacifica Banner, 1948
Foxiphalus falciformis Jarrett & Bousfield, 1994
Gnathopleustes serratus Bousfield & Hendrycks, 1995
Grandifoxus dixonensis Jarrett & Bousfield, 1994
Holmesimysis nudensis Holmquist, 1979

Lepas pacifica Henry, 1940
Megamoera bowmani Jarrett & Bousfield, 1996
Monocorophium carlottensis Bousfield & Hoover, 1997
Mysidella americana Banner, 1948
Najna rugosum Bousfield, 1981
Nebria charlottae Lindroth, 1961
Nebria louisae Kavanaugh, 1984
Pacifacanthomysis nephrophthalma (Banner, 1948)
Paralomis multispina (Benedict, 1894)
Paramoera carlottensis Bousfield, 1958
Paramoera columbiana Bousfield, 1958
Parapagurus pilosimanus benedicti de Saint Laurent, 1972
Prophryxus alascensis Richardson, 1909
Pseudoliropus vanus Laubitz, 1970
Quadrimaera carla Krapp-Schickel & Jarrett, 2000
Rhachotropis americana Bousfield & Hendrycks, 1995
Rhachotropis calceolata Bousfield & Hendrycks, 1995
Stegocephalxia penelope Moore, 1992
Synidotea cornuta Rafi & Laubitz, 1990
Synidotea minuta Rafi & Laubitz, 1990
Synidotea nodulosa (Krööyer, 1848)
Thorlaksonius grandirostris Bousfield & Hendrycks, 1994
Thysanopoda acutifrons Holt & Tattersall, 1905

Bryozoa
Porella argentea Hincks, 1884
Smittina spathulifera (Hincks, 1884)

Echinodermata
Chiridota albatrossi Edwards, 1907
Craterobrisinga synaptoma (Fisher, 1917)
Evasterias troschelii (Stimpson, 1862)
Freyella microplax (Fisher, 1917)
Henricia leviuscula inequalis (Stimpson, 1857)
Ophiacantha bathybia Clark, 1911
Ophiopthalmus eurypoma Clark, 1911
Ophiura leptoctenia Clark, 1911
Parastichopus leucothele Lambert, 1986
Psathyrometra profundorum Clark, 1908
Ptilocrinus pinnatus Clark, 1907
Solaster stimpsoni Verrill, 1880

Urochordata
Agnesia septentrionalis Huntsman, 1912

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